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EARTHQUAKE HAZARDS REDUCTION ACT REAUTHORIZATION

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HEARING

BEFORE THE
SUBCOMMITTEE ON
SCIENCE, TECHNOLOGY, AND SPACE
OF THE
COMMITTEE ON COMMERCE,
SCIENCE, AND TRANSPORTATION
UNITED STATES SENATE
NINETY-NINTH CONGRESS
FIRST SESSION
ON
REAUTHORIZATION OF THE EARTHQUAKE
HAZARDS REDUCTION ACT

MARCH 19, 1985

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EARTHQUAKE HAZARDS REDUCTION ACT REAUTHORIZATION

TUESDAY, MARCH 19, 1985

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
Washington, DC.

The subcommittee convened, pursuant to notice, at 10:08 a.m., in room SD-G50, Russell Senate Office Building, Hon. Slade Gorton (chairman of the subcommittee) presiding.

Staff members assigned to this hearing: David Cheney, professional staff member and Pat Windham, minority professional staff.

OPENING STATEMENT BY SENATOR GORTON

Senator GORTON. The meeting will please come to order.

Just 16 days ago, a major earthquake struck Chile and reminded us of the awesome destructive power of earthquakes. It killed 176 people and injured nearly 2,500. More than 370,000 people were left homeless.

The same hazards are present in the United States. The earthquake the geologists give a 50-50 chance of striking southern California in the next 30 years is likely to be the most devastating event on U.S. soil since the Civil War, possibly causing 20,000 deaths and $50 billion in damages. An earthquake in the Puget Sound area could cause 10,000 casualties and leave 20,000 homeless.

Earthquakes are not only a west coast problem. Earthquakes in the Central and Eastern United States are less frequent but potentially even more damaging than earthquakes in the West. Thirty-nine States and 70 million people in the United States are exposed to at least moderate earthquake hazards.

There is potential still largely unfulfilled of drastically reducing the damages from earthquakes. In 1975, the Chinese successfully predicted an earthquake and evacuated the city of Haicheng some 10 hours before the city was destroyed. Some people estimate the prediction saved 100,000 lives. Eighteen months later, an unpredicted earthquake struck the unprepared city of Tangshan and killed over 240,000 people. These two events illustrate the potential of reducing damages from earthquakes—and the tragedy of failing to do so.

In 1977, Congress passed the Earthquake Hazards Reduction Act to establish a coordinated Federal program to reduce the hazards posed by earthquakes. In today's authorization hearing, we want to review the progress made under the National Earthquake Hazard Reduction Program and determine if changes need to be made. This morning we will receive testimony from representatives of the four Federal agencies conducting activities under the Earthquake Hazards Reduction Act as well as from two outside experts.

In previous years the committee has been concerned about the management and coordination of the program by the Federal Emergency Management Agency, and we look forward to hearing about the progress that has been made. We will also be examining the 1986 budget. We are all aware of the current budget limitations, but we must be careful that cuts of a few million dollars do not cost us many lives and billions of dollars after an earthquake.

Senator Gore, do you have a statement?

OPENING STATEMENT BY SENATOR GORE

Senator **Gore**. I am pleased to participate in this hearing on the Earthquake Reduction Act.

Assisting States and localities to prepare for the possibility of earthquakes is an important Federal task and the Earthquake Reduction Act is the centerpiece of the Federal effort. Through the establishment of the National Earthquake Hazards Reduction Program, the act aspires to bring about a coordinated effort among several Federal agencies to help minimize the potentially disastrous consequences of earthquakes.

Last year, as a Member of the House of Representatives and chairman of its Science and Technology Subcommittee on Investigations and Oversight, I chaired two hearings on earthquakes in the Eastern United States. A great deal of attention has been paid to earthquakes in the Western United States, but it is only recently that careful study has been made of the cause and effects of eastern quakes.

On the average, a damaging earthquake occurs in the Eastern United States every 25 years. A serious quake occurs once every 50–100 years. The largest earthquake ever recorded in the 48 contiguous States occurred near New Madrid, MO, in 1811. That quake had a magnitude of 8.7 on the Richter scale, and it is claimed that the shock waves from it rang church bells in Boston. Other large quakes have occurred in Charleston, SC, in 1886, and in the Boston-New York area.

I have a particular concern in this matter because west Tennessee and the city of Memphis—the largest city in Tennessee—lie extremely close to the New Madrid fault line. An earthquake similar to the 1811 quake could cause a tremendous amount of damage to that area.

Fortunately, the people of Memphis are well aware of the possibility of a major earthquake and are taking steps to prepare for it. For example, numerous public education efforts have been conducted. Just last month, in fact, the city sponsored an "Earthquake Awareness Week," and later this month, a major conference on earthquakes will take place in Memphis. Steps are also being taken to ensure that buildings are made "earthquake proof." Moreover, the Earthquake Information Center located at Memphis State University does an excellent job of monitoring earthquake activity in the region and keeping the public informed.

A significant step in addressing earthquake preparation in the Eastern United States was taken in April 1984 when the Federal Emergency Management Agency announced the funding of a Central United States Earthquake Consorium. The member States of the consortium are Tennessee, Arkansas, Illinois, Indiana, Kentucky, Mississippi, and Missouri. The consortium has established an earthquake monitoring center and is in the process of developing a 5-year quake preparedness plan. I am anxious to hear from the FEMA representative here today about the progress of that effort.

Mr. Chairman, in my comments I have focused on earthquakes in the Eastern United States. This is not because I am not concerned about quakes in the Western States, but rather because I worry that not enough attention is being given to eastern earthquakes. As a Member of the House, I sought to highlight this deficiency in our Federal earthquake program, and I hope to continue to do so as a member of this subcommittee. I am pleased that this is one of the questions to be addressed at this hearing.

Senator Hollings has a conflicting schedule and could not be here in person, but has asked me to insert his statement in the record.

[The statement follows:]

OPENING STATEMENT BY SENATOR HOLLINGS

Mr. Chairman, recent events have demonstrated just how hazardous earthquakes are and how important it is that we do all we can to minimize the dangers they pose to life and property. An earthquake in Chile earlier this month killed scores of people and caused billions of dollars in property damage. Less than two years ago, residents of Coalinga, California, watched in horror as a series of earthquakes reduced their town to rubble. Damage was in the hundreds of millions of dollars.

By one estimate, the world's earthquakes now kill an average of 40,000 people a year. We now know that they threaten both the American Midwest and East as well as the Pacific Coast.

In the past two years the National Earthquake Hazards Reduction Program has made progress. We finally have a five-year plan, which was due in 1981. The Federal Emergency Management Agency has strengthened its staff and its management of the overall program. Information on earthquake hazards and mitigation meaures has been disseminated to state and local officials and to the engineering community. Recent research has taught us much about earthquakes that occur east of the Rocky Mountains, and scientists are now poised to monitor the expected earthquake along the Parkfield section of the San Andreas fault.

Much remains to be done, however. We are only beginning to understand the geological processes that caused the disastrous New Madrid and Charleston earthquakes of the 19th Century. Such "intraplate" earthquakes are poorly understood. Yet evidence from the Charleston area now confirms that eastern earthquakes occur periodically, and suggests that wide sections of the American East may be threatened by major tremors.

In addition, short-term earthquake prediction has proven more difficult than we first imagined. More work is needed here. Our understanding of how structures behave in earthquakes, while growing, still is preliminary. Yet the Administration once again proposes elimination of the Center for Building Technology at the National Bureau of Standards. Finally, more work is needed to help states and communities develop zoning plans and building codes that reduce the chances of widespread destruction.

Mr. Chairman, I look forward to receiving the testimony from Mr. Speck and the other agency officials who come before us today. I am especially pleased that Professor Lindbergh will testify. Dr. Lindbergh teaches at my alma mater, the Citadel. I know that he and our other witnesses will shed light on the important issues before us. Earthquakes remain a serious threat to our nation and our people. It is essential that we have a sound program to understand them and to reduce their hazards.

Senator **Gorton**. Thank you Senator Gore.

I am pleased that the long-awaited 5-year plan for the program has been released, and we look forward to assessing it. We want to pay special attention to how the program is making the States better prepared for earthquakes, and we will be hearing from Mr. Hugh Fowler of the Washington State Department of Emergency Management on that subject.

We will also hear from Dr. Charles Lindbergh of the department of civil engineering at the Citadel, Charleston, SC, on some of the special problems of east coast earthquakes.

The hearing will start with a panel of representatives of the Federal agencies which are conducting activities under the Earthquake Hazards Reduction Act. In order of presentation they are Dr. Samuel Speck, of the Federal Emergency Management Agency, followed by Dr. Dallas Peck of the U.S. Geological Survey, Dr. Nam Suh of the National Science Foundation, and Mr. Raymond Kammer of the National Bureau of Standards.

Gentlemen, we welcome you to the hearing, and look forward to your testimony, starting with that of Dr. Speck.

STATEMENTS OF DR. SAMUEL W. SPECK, ASSOCIATE DIRECTOR FOR STATE AND LOCAL PROGRAMS AND SUPPORT, FEDERAL EMERGENCY MANAGEMENT AGENCY; DR. DALLAS PECK, DIRECTOR, U.S. GEOLOGICAL SURVEY, ACCOMPANIED BY DR. JOHN FILSON, CHIEF, OFFICE OF EARTHQUAKES, VOLCANOES, AND ENGINEERING; DR. NAM P. SUH, ASSISTANT DIRECTOR FOR ENGINEERING, NATIONAL SCIENCE FOUNDATION; AND RAYMOND G. KAMMER, DEPUTY DIRECTOR, NATIONAL BUREAU OF STANDARDS

Mr. **Speck**. Thank you, Mr. Chairman.

I am pleased to appear before this session of the Senate Committee on Commerce, Science, and Transportation Subcommittee on Science, Technology, and Space to present the Federal Emergency Management Agency's comments on the National Earthquake Hazards Reduction Program in connection with the reauthorization of the Earthquake Hazards Reduction Act of 1977.

In these remarks, I will summarize my testimony, which is being submitted in its entirety for the record.

Senator **Gorton**. And it will be included in the record.

Mr. **Speck**. Thank you.

In my oral testimony, I would like to do three things: First, briefly summarize the activities and allocations of responsibilities under the National Earthquake Hazards Reduction Program; second, summarily describe FEMA's responsibilities within that program; and third, briefly detail the fiscal year 1985 and projected fiscal year 1986 FEMA outputs under the program.

Simply put, the Earthquake Hazards Reduction Act of 1977's purpose is the reduction of the risk to life and property in the United States from future earthquakes.

In creating the program, Congress brought together the earthquake hazard-related research programs already well underway of the U.S. Geological Survey, the National Science Foundation, and the National Bureau of Standards with the activities of FEMA to form an integrated and comprehensive program.

These agencies, as you have already indicated, constitute the four principal agencies of the National Earthquake Hazards Reduction Program. Congress has designated FEMA as the lead agency for that program with responsibility for developing, leading, and coordinating the program.

As such, FEMA chairs a variety of interagency coordinating mechanisms at both the senior policy and program manager levels. These have proven to be effective in dealing with the range of issues the program faces.

FEMA oversees and coordinates the preparation and submission on behalf of the President of the program's annual report to Congress each year. FEMA also has submitted to Congress on behalf of the administration proposed legislation to reauthorize appropriations under the Earthquake Hazards Reduction Act totaling $68,899,000 for fiscal year 1986 and sums as may be necessary for fiscal year 1987.

This legislation basically freezes the total authorized amount under the Earthquake Hazards Reduction Act at the level approximating that authorized for fiscal year 1985, which represented a substantial increase over the previous fiscal year.

Working through the interagency coordinating mechanisms, FEMA has prepared the 5-year plan for the program which is required by the act. It was transmitted to Congress on January 4, 1985. It outlines the programs of the principal agencies in carrying out their responsibilities under the National Earthquake Hazards Reduction Program.

The time period covered by the plan includes fiscal years 1985 through 1989. The plan translates the purpose and objectives of the Earthquake Hazards Reduction Act into a program consisting of five major elements and outlines the specific goals and objectives for each element.

These elements, which I will now briefly discuss, are listed on the chart that you have to your left and my right, and you will notice the chart lists the basic elements, the subelements under each of those basic five elements, and on the right-hand side of the chart the agency with the principal responsibility for carrying out those elements.

The elements are, as you can see from the chart, first hazard delineation and assessment, or in other words what do earthquakes do; the second, earthquake prediction research so that we may better do what the Chinese did in the example you gave, Mr. Chairman, of predicting an earthquake before it happens; third, seismic design and engineering research; fourth, preparedness planning and hazard awareness—by that we mean public education about earthquakes; and finally, five, fundamental seismological studies, that is, what are the basic causes of earthquakes.

FEMA has submitted legislation which would change the current requirement for an annual update of the 5-year plan to updates as necessitated by events or at least every 5 years. The reason for this is simply the extraordinary amount of staff time and resources that it takes to bring about an annual update, and the fact that programmatic activities in this area are usually undertaken on a multiyear cycle, and therefore an annual update would not be particularly appropriate.

FEMA, through submission to Congress of the annual report, will continue to report regularly on progress being made by the agencies to accomplish the objectives in the 5-year plan.

Mr. Chairman, the committee should have already received the national earthquake hazards reduction 5-year plan, and in addition to that should have already received the national earthquake hazards reduction overview, and a copy of the annual report.

In terms of FEMA's Earthquake Program activities, as in all matters related to public health and safety, State and local governments bear the primary responsibility for the protection of life and property in the event of a serious catastrophic earthquake.

They and individuals and groups in the private sector are also the ultimate users of information generated by the National Earthquake Hazards Reduction Program. To assist State and local governments to enhance their overall emergency management capabilities, FEMA developed the Integrated Emergency Management System, known as IEMS.

IEMS stresses the preparedness elements common to emergencies across the full spectrum, while at the same time recognizing elements unique to specific types of emergencies.

Guidance for the implementation of the IEMS approach was developed in 1983, field tested in 1984, and is undergoing full field implementation throughout the United States in 1985. The IEMS functional approach to comprehensive emergency management was funded last year by approximately $100 million of civil defense funds in direct program and training support to State and local governments.

Mr. Chairman, I have indicated here the basic functional elements that we are working with State and local governments to develop, functional elements that you need to have the capability to do regardless of the kind of threat or hazard that you may confront.

My purpose for bringing this to your attention is that I think we should not only look at where we are going in earthquake preparedness, but also look at what we are doing that is specific to earthquake preparedness, as well as what we are doing generically that is critical for an effective earthquake program or any program to enable an effective response to any kind of hazard that may confront us.

Under the National Earthquake Hazards Reduction Program, FEMA has responsibility for five areas of activity in addition to its overall leadership role. You will see those listed on the chart again on your left, my right. FEMA conducts these activities within the framework provided by IEMS.

I will now briefly discuss the elements of FEMA's Earthquake Program in terms of past accomplishments and planned activities for the future. In order to do that, I have listed on two charts what we expect as our program accomplishments in fiscal year 1985, which is on your left, in fiscal year 1986, which is on your right.

In terms of the first element, seismic design and construction, that was on the previous chart, the partial or total collapse of structures is the main cause of earthquake injuries and deaths.

However, casualties can also occur not only from the buildings themselves but from the secondary effects of failed lifelines, such as fires caused by ruptured natural gaslines.

In order to lessen these threats over the long term, FEMA supports activities which can enhance the seismic safety of new and existing buildings as well as lifelines. The Interagency Committee on Seismic Safety in Construction has prepared and issued a draft seismic standard for new Federal buildings which is currently being updated and balloted by the Federal agencies. FEMA is presently focusing on ways to ensure wide acceptance and application of this standard.

With respect to new non-Federal buildings, a multiyear effort by the Building Seismic Safety Council under contract to FEMA has resulted in the publication of National Earthquake Hazards Reduction Program recommended provisions for the development of seismic regulations for new buildings in draft form.

Final balloting of this document by the BSSC member organizations is now scheduled for the fall of 1985. These provisions will be available for our use by code groups, State and local governments, and the design professions.

Last summer FEMA contracted with ABE, which is a term that refers to Applied Technology Council, Building Seismic Safety Council, and the Earthquake Engineering Research Institute joint venture for the development of a comprehensive and detailed plan to address seismic vulnerability of existing buildings.

This plan is expected to be ready by the end of fiscal year 1985. Fiscal year 1986 funds will be used to start the most urgent and high priority items identified by this report. During the spring, FEMA plans to contract for a long-range plan on how to enhance seismic safety of new and existing lifelines.

This plan is not expected to be ready before the end of fiscal year 1986, with implementation therefore extending into the outyears.

Due to the complexity of the issues surrounding lifelines, this area of seismic design promises to be one of the most challenging tasks we face in future years.

In terms of State and local hazards reduction programs, major objectives of the National Earthquake Hazards Reduction Program include developing in areas of seismic risk means of reducing the risks from earthquakes, providing warning of earthquakes, organizing State and local emergency services, and planning for reconstruction and redevelopment after an earthquake.

Twelve areas of high population, high risk have been identified, and in fiscal year 1985 for the first time FEMA is supporting earthquake hazards reduction projects in all 12 of these areas.

The 12 areas are: Anchorage, AK; Puget Sound, WA; southern California; northern California; Honolulu, HI; Salt Lake City, UT; the Central United States, that is, the New Madrid area: Charleston, SC; Boston, MA; New York; State; Puerto Rico; and the Virgin Islands.

These areas are all at various stages in implementing their earthquake programs. Some are at relatively early stages of vulnerability assessment, while others are involved in preparedness and response planning and mitigation and Federal response activities.

Mr. Chairman, we have detailed in the formal testimony the specific activities and stages where we are now in each of those 12 areas for members of the committee.

With the program's expansion to all high risk areas, FEMA recognized the importance of developing a standardized earthquake loss estimation methodology for use throughout the entire Nation. We plan to initiate this effort this year.

Currently FEMA is completing work on a formal civil preparedness guide which describes the tasks and activities that comprise a balanced State and local Earthquake Hazards Reduction Program. It is expected to be available for us in planning fiscal year 1986 projects.

This CPG is a major advance in the availability of Earthquake Program guidance.

In terms of Federal response planning, State and local resources will be inadequate to respond to a truly catastrophic earthquake. Response from the Federal Government, both from the local geographic area and the entire Nation, will be required.

Therefore, in recognition of the increasing threat of a catastrophic earthquake in California, as well as the possibility of catastrophic earthquakes in other areas, FEMA initiated a response planning effort that involves the entire Federal Government.

The third draft of the resulting Federal response plan was table top exercised in RESPONSE 84, which was based on a simulated catastrophic earthquake on the San Andreas Fault. The lessons learned from RESPONSE 84 were incorporated into the fourth draft of the plan, which will be field tested in RESPONSE 85 in June 1985 in California.

Future work will initiate development of Federal regional plans and include exercises to maintain and update the national plan.

In regard to mitigation and multihazard preparedness planning, until now earthquake preparedness planning has been conducted with an exclusive concentration on reducing seismic risk. However, earthquakes also trigger multiple and simultaneous disasters such as fires, floods from ruptured dams, landslides, and toxic spills.

For areas where earthquake recurrence periods are long and current seismicity is low, earthquake preparedness measures may be politically and economically feasible only if they are combined with those to reduce other hazards.

A multihazard approach to planning is under way in Ogden, UT, to assess the combined risks from seismic hazards, dam failure, and floods. This effort is expected to provide cost-effective and manageable preparedness strategies and recommendations for the short-term mitigation of existing hazards and for long-term land use planning to avoid them.

The project should be completed next year, at which time its transferability will be assessed, and, Mr. Chairman, I had the opportunity to meet with the people in Utah this past week to discuss the progress that is being made, and to look at the interrelationship between the Wasatch Fault and the dams that are just over the first tier of mountains that would be at considerable risk in the event of an earthquake there.

The banking and insurance industries are the subject of consideration with respect to earthquake hazard mitigation because of the critical functions that they perform in our society. FEMA is planning to examine them from two points of view, as agents for bringing about abatement of seismic risks through their loan insurance and related practices, and as institutions the continuing functioning of which is vital to restoration of community life after a damaging earthquake.

The goal is to reach policy conclusions by the end of fiscal year 1986.

Earthquake education and information transfer is another critical element of our program. In order for individuals, organizations, and governmental units to most effectively plan for, respond to, and take appropriate recovery and mitigation actions related to the earthquake hazard, a Comprehensive Earthquake Education and Information Transfer Program is essential.

At the end of fiscal year 1984, FEMA completed the development of a Multiyear Earthquake Education Management Program which identifies milestones and expected accomplishments and facilitates analysis, evaluation, and identification of future funding priorities.

FEMA has promoted community outreach efforts through support since 1983 of two pilot earthquake education centers in Charleston, SC, and Memphis, TN, and a pilot project to reduce the vulnerability of the Seattle, WA, school population to the consequences of earthquakes.

Mr. Chairman, I have with me some of the outputs of some of those programs. This is the guidebook for developing a School Earthquake Safety Program. In fiscal year 1986, these efforts will be completed and evaluated for transferability.

FEMA has also initiated competitive challenge grants to stimulate local public information demonstration projects, provided a grant to the Children's Television Workshop, producer of TV's Sesame Street, to develop a Multihazard Program for youth, and initiated a series of emergency information exchanges.

Again, Mr. Chairman, I have a number of the various publications in terms of earthquake information that are currently available to the public.

With the USGS, FEMA sponsors workshops designed to increase the hazard awareness of elected officials and influential public and private policymakers in high risk areas. Since 1981, 12 workshops have been held or are now planned.

Finally, through the NETC, the National Emergency Training Center at Emmitsburg, FEMA has developed a course entitled "Earthquake Hazard Mitigation for Utility Lifelines," the first of a series of special topical courses on hazard mitigation. Other courses will be developed to address such topics as earthquake fire hazards in highrise, high occupancy buildings and nonstructural earthquake hazard mitigation for hospitals.

In 1984, the southern California Earthquake Preparedness Project, known as SCEPP, delivered to FEMA the products it had developed since its creation in 1980. FEMA has reviewed these materials to determine their transferability to areas outside of southern California, and the most effective means of disseminating them to other areas. We expect to have them available for distribution later this year.

Thank you. That concludes my comments, Mr. Chairman. I will be glad to answer questions at the appropriate time.

[The statement follows:]

STATEMENT OF DR. SAMUEL W. SPECK, ASSOCIATE DIRECTOR, STATE AND LOCAL PROGRAMS AND SUPPORT, FEDERAL EMERGENCY MANAGEMENT AGENCY

INTRODUCTION

I am pleased to appear before this session of the Senate Committee on Commerce, Science and Transportation, Subcommittee on Science, Technology and Space to present the Federal Emergency Management Agency's (FEMA) comments on the National Earthquake Hazards Reduction Program (NEHRP) in connection with the reauthorization of the Earthquake Hazards Reduction Act of 1977. My discussion today will cover the objectives of the law, FEMA's leadership role in the NEHRP, the roles of other Federal agencies, the Five-Year Plan, the five major elements which comprise NEHRP, and the five major elements of FEMA's earthquake hazards reduction program.

THE NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM

The Earthquake Hazards Reduction Act of 1977 (P.L. 95-124), as amended, has as its purpose the reduction of the risks to life and property in the United States from future earthquakes through the establishment and maintenance of an effective earthquake hazards reduction program. The objectives of the NEHRP include development and improvement of the Nation's capabilities with respect to seismic design and construction; land-use policy decisions and building activity; earthquake prediction techniques and warning systems; coordinated preparedness response and recovery planning; public education; identification and characterization of the earthquake hazard; and research.

In creating the NEHRP, Congress brought together the earthquake hazard related research programs, already well underway, of the U.S. Geological Survey (USGS), National Science Foundation (NSF), and the National Bureau of Standards (NBS) with the activities of FEMA to form an integrated and comprehensive Federal program.

FEMA'S Leadership Role

FEMA s overall mission is to coordinate Federal emergency management activities (preparedness, response, recovery, and mitigation) for all types of disasters - natural and manmade - and to provide technical and financial assistance to State and local governments in carrying out their emergency management programs. With this in mind Congress designated FEMA as the lead agency for the NEHRP, with responsibility for developing, leading, and coordinating this national program.

FEMA has provided leadership to the program in the following ways:

- FEMA has submitted to the Congress on behalf of the Administration proposed legislation to reauthorize appropriations under the Earthquake Hazards Reduction Act totaling $68,899,000 for Fiscal Year 1986 and sums as may be necessary for Fiscal Year 1987. This legislation basically freezes the total authorized amount under the Earthquake Hazards Reduction Act at a level approximating that authorized for Fiscal Year 1985.

- FEMA has stimulated the creation of the Policy Coordinating Group, composed of senior policy level officials of the four principal agencies (USGS, NBS, NSF, and FEMA), to provide guidance on overall program policy issues and to oversee the NEHRP planning, budget, and evaluation processes. FEMA chairs this important coordinating forum.

- FEMA established and chairs the Interagency Coordinating Committee (ICC) of the NEHRP. The ICC is composed of program-manager level representatives of the four principal agencies assigned responsibilities under the program, and other departments and agencies which conduct earthquake related programs. The ICC provides a setting for the staff to meet regularly and resolve the operational issues facing the agencies in meeting the goals of the NEHRP. The ICC has become, over the past year, stronger than ever.

- FEMA chairs the Earthquake Work Group in support of the Emergency Mobilization Preparedness Board (EMPB). The EMPB was created by the President to ensure that the Nation would be capable of responding effectively to major peacetime and wartime emergencies. The Earthquake Work Group is addressing national mobilization and preparedness issues associated with the consequences of a catastrophic earthquake.

- FEMA has established an Earthquakes and Natural Hazards Programs Division within its Office of Natural and Technological Hazards to provide a focus for earthquake related activities within our agency.

- FEMA, working through the ICC and Policy Coordinating Group mechanisms previously explained, has prepared the Five-Year Plan for the National Earthquake Hazards Reduction Program. The plan, which details the activities to be undertaken by the principal agencies, will be discussed in greater detail below.

- FEMA has continued to promote a strong seismic mitigation program applicable to the Federal community through support of the Interagency Committee on Seismic Safety in Construction (ICSSC). FEMA participates in the ICSSC Steering Committee and provides financial and lead agency support to the National Bureau of Standards, which functions as the Committee's Secretariat. This Committee was nearly dormant two years ago, but since then, largely through FEMA's leadership role, it has been revitalized.

- FEMA chairs the Subcommittee on Federal Earthquake Response Planning of the ICC. This Subcommittee guides the development of the framework and strategies upon which the National Plan for Response to a Catastrophic Earthquake is based. This plan will be discussed further under FEMA's earthquake program activities.

o FEMA oversees and coordinates the preparation of and submits, on behalf of the President, the NEHRP Annual Report to Congress each year. The law requires that such a report be prepared following each fiscal year, discussing the status of the NEHRP and describing and assessing the progress made during the preceding fiscal year in reducing the risks of earthquake hazards.

The General Accounting Office (GAO), in the latter part of 1982, conducted an evaluation of FEMA's efforts to carry out the lead agency role for the NEHRP, and published a report entitled "Stronger Direction Needed for the National Earthquake Program," in July 1983. The principal recommendation of the Report was to

> ...formalize and strengthen the role of the Earthquake Policy Review Group as the program's oversight and management body by scheduling regular meetings and instituting a process that will bring important issues before it for decision, including establishing program goals, priorities, budgets, and target dates; and requesting, if necessary, specific Congressional funding for its activities.

FEMA responded to this recommendation by having an official charter for the renamed Policy Coördinating Group approved by the members and publishing this charter in the *Federal Register* on July 20, 1984. FEMA now chairs meetings at approximate six-month intervals and records the agendas, minutes, and follow-up actions. As necessary, meetings may be scheduled more frequently. FEMA also used this group to coordinate the development of the recently completed Five-Year Plan.

An additional recommendation of the GAO evaluators, related to FEMA's lead role was that the Agency should have a dedicated staff with appropriate technical expertise in order to provide effective leadership for this complex, technical program. Since the report was published, FEMA has improved staff capacity by focusing earthquake program activities in a newly created Earthquakes and Natural Hazards Programs Division (as mentioned earlier). This staff has been free of any reorganizations since November 1983 and the continuity of assignments has allowed staff to develop their professional competence. FEMA also arranged with the USGS for the latter to conduct a course in February 1985 for FEMA's headquarters and regional earthquake program managers and staff on the history, causes, and effects of earthquakes in the United States. Based on the success of this course, future courses on additional subjects may be developed.

Other Participants in the NEHRP

Three agencies have principal roles in the NEHRP, in addition to FEMA. These are the USGS, NBS, and NSF. The USGS conducts basic studies on the nature of earthquakes and their physical processes, hazard delineation and risk analysis, earthquake prediction, and induced seismicity, as well as information dissemination and outreach efforts. The NSF funds basic research on earthquake processes and other fundamental studies, and earthquake engineering research. To supplement FEMA's current staff capacity, the Agency has arranged for and funded the NBS to function as technical monitor on some projects concerning the development of seismic design and construction standards.

In addition to the four principal agencies, there are a number of other agencies that play supporting roles in the NEHRP. These include the Nuclear Regulatory Commission, National Aeronautics and Space Administration, National Oceanic and Atmospheric Administration, the Veterans Administration, and the Departments of Transportation, Defense, and Housing and Urban Development. In all, there are over twenty agencies that have a role in the NEHRP, stemming at least from their responsibilities in the National Plan for Response to a Catastrophic Earthquake.

The National Earthquake Hazards Reduction Act specifies at several points that the private sector be involved to the extent possible in the various activities of the NEHRP. Elements of the private sector are involved in research and other projects related to the objectives of the NEHRP, and are also often the ultimate users of information produced and disseminated by participating government agencies.

FIVE-YEAR PLAN FOR THE NEHRP

The Five-Year Plan for the NEHRP is required by Section 5 of the Earthquake Hazards Reduction Act of 1977, as amended by P.L. 96-472 of October 19, 1980. The section provides that the Director of FEMA shall "... compile and maintain a written program plan for the program ... which plan will recommend base and incremental budget options for the agencies to carry out the elements and programs specified ... and which plan shall be ... transmitted to the Congress and shall be updated annually...."

Since the inception of the program in 1977, the efforts of NSF and USGS had been guided by an earlier plan published jointly by the two agencies ("Earthquake Prediction and Hazard Mitigation: Options for USGS and NSF Program," September 15, 1976). While providing valuable guidance at the beginning, this plan did not include the efforts of NBS and FEMA did not yet exist. Further, the report only covered fiscal years through 1980, the limit of the Act's original authorization.

The development and completion of the Five-Year Plan was a longer and more complicated process than anyone involved anticipated when the effort began. The final Plan was completed and transmitted to Congress on January 4, 1985. An initial plan was developed by the principal agencies and was completed in 1983. Then FEMA convened a panel of 25 experts in a variety of earthquake related fields to provide an independent review of the document. This panel was headed by Karl Steinbrugge, a structural engineer and internationally recognized expert on earthquake damage. It was charged with providing the Chairman of the ICC "... with an assessment of its (the plan's) adequacy in respect to such topics as general direction, comprehensiveness, gaps or overlaps, and responsiveness to the objectives of the NEHRP, as established by law."

During Fiscal Year 1984, the NEHRP Policy Coordinating Group and, subsequently, the Office of Management and Budget (OMB) reviewed the recommendations of the independent advisory panel (submitted in Fiscal Year 1983) and established guidelines for revision of the plan by the principal agencies to conform with the President's budget. The independent panel had provided both a high and low budget scale for the proposed activities in the plan, and the reworking of the plan according to the guidelines provided as part of the Policy Coordinating Group and OMB reviews resulted in a level of activity between the two.

Legislation has been submitted which would change the requirement to submit an annual update to the five-year program plan required by section 5(b)(2)(E) to a requirement for submission of the plan when needed, but in any event at least every five years. Also, the section would be revised to eliminate obsolete dates, and required details to be included in the plan. The reason for this change is two fold; (1) the process of preparing the plan was time and staff intensive and we anticipate that an annual update would require commensurate resources, and (2) programmatic activities in this area are usually undertaken on a multiyear cycle; therefore an annual update would be ineffective. FEMA, through submission to Congress of the annual report, will continue to report regularly on progress being made by the agencies to accomplish the objectives in the Five-Year Plan.

The plan outlines the programs of the principal agencies in carrying out their responsibilities for the five basic elements of the NEHRP. The time period covered by the plan includes Fiscal Years 1985 through 1989.

The plan translates the purpose and objectives of the Earthquake Hazards Reduction Act into a program consisting of five major elements, and outlines specific goals and objectives for each element. The elements, along with brief descriptions of the activities they encompass, are as follows:

1. Hazard Delineation and Assessment
2. Earthquake Prediction Research
3. Seismic Design and Engineering Research
4. Preparedness Planning and Hazard Awareness
5. Fundamental Seismological Studies

1. Hazard Delineation and Assessment

Information about the earthquake risk is the foundation upon which safety measures rest: land use planning; design and construction; disaster preparedness, response and recovery; public information and education activities; and responses to predictions. Major activities under this element involve (1) determining the tectonic framework and earthquake potential of various zones in the United States, and (2) delineating, evaluating and documenting earthquake hazards and risks in urban and other critical areas of the United States. Projects conducted under this element include: regional monitoring and earthquake potential studies, national and regional earthquake hazards assessment, and post-disaster mitigation studies.

2. Earthquake Prediction Research

Accurate earthquake prediction can provide a foundation for preparedness actions that may reduce human suffering and social disruption, while posing intriguing and fundamental scientific questions. One of the most challenging problems facing the physical science community is to develop reliable methods for the timely prediction of damaging earthquakes. Activities conducted under this element include the following obtaining and analyzing data on precursory phenomena performing prediction experiments, performing theoretical, laboratory and fault zone studies to understand the physical processes involved in the occurrence of earthquakes, and developing a better understanding of induced seismicity.

3. Seismic Design and Engineering Research

Significant advances in understanding the response of structures to earthquake motions are being incorporated into the design of tall buildings, dams, nuclear power plants, liquified natural gas facilities, and more. However, today's knowledge is far from complete. Activities under this element are directed towards improvements in: model codes and regulations and manuals of practice for improved seismic design; efforts to educate engineers, public officials, architects, and construction personnel about improved practices; research to understand the response of structures to earthquakes and develop better information on actual and estimated ground motion; and continued progress within the Federal Government to apply proper practices to its own building projects.

4. Preparedness Planning and Hazard Awareness

Improvements in seismic design and construction primarily affect new construction. However damages in heavily populated and industrialized areas can cause tens of thousands of casualties and damages in the billions of dollars. Therefore, it is critical to mitigate the impacts of earthquakes and prepare for an effective response. Activities within this element are directed toward improving the capabilities of all elements of the public and private sectors to mitigate the consequences of and respond to an earthquake disaster (or the prediction of an earthquake), and developing knowledge about the decision-making and economic impacts of mitigation and preparedness. Specific projects include the development of a management strategy for coordinating earthquake hazards reduction activities, development and testing of a Federal Response Plan and strengthening of State and local preparedness planning, consolidation of earthquake preparedness planning with that for other hazards to increase the efficiency of all, development and implementation of an earthquake education and information transfer plan, and examination of the societal factors associated with the adoption and application of technological and social adjustments to earthquake hazards.

5. Fundamental Seismological Studies

Basic research is required to understand the physical processes that eventually cause earthquakes. The disciplines and technologies involved are numerous, including seismology, geodesy, satellites, lasers, and computer modeling. The activities of this element are directed toward better understanding of plate tectonics and the earthquake process; installation, operation and maintenance of an improved global and national network or seismograph stations; collection and analysis of information on the occurrence and effect of earthquakes; and support of basic and applied research to ensure that data collection and analytical techniques keep pace with advances in instrumentation and theoretical seismology.

FEMA's EARTHQUAKE PROGRAM ACTIVITIES

As in all matters related to public health, safety, and welfare, State and local governments bear the primary responsibility for the protection of life and property in the event of a serious or catastrophic earthquake. The functions of emergency preparedness planning, warning, response, recovery, and mitigation must be carried out at these levels of government, with the assistance, cooperation, and support of the Federal Government. To assist State and local governments to enhance their overall emergency management capabilities, FEMA developed the Integrated Emergency Management System (IEMS). IEMS is designed to enable State and local governments to utilize available funds and resources with optimum effectiveness and efficiency. It does so by stressing an integrated functional approach to the management of emergencies across a full spectrum, including natural disasters such as tornadoes, hurricanes, floods and earthquakes technological disasters such as explosions, release of hazardous materials, accidents involving radiological materials, nuclear power plant accidents, resource shortages; and possible attack.

IEMS stresses the preparedness elements common to emergencies across the full spectrum while at the same time recognizing elements unique to specific types of emergencies. Guidance for the implementation of the IEMS approach was developed in 1983, field tested in 1984, and is undergoing full field implementation in 1985. The IEMS functional approach to comprehensive emergency management was funded last year by approximately $100 million of civil defense funds in direct program and training support to State and local governments.

The Earthquake Hazards Reduction Act, while obviously hazard specific, recognized in its original language the benefits that could accrue to overall emergency preparedness from the planning and preparedness activities related to a single hazard. Section 2(7) states:

> The implementation of earthquake hazards reduction measures would, as an added benefit, also reduce the risk of loss, destruction, and disruption from other natural hazards and manmade hazards, including hurricanes, tornadoes, accidents, explosions, landslides, building and structural cave-ins, and fires.

Under the five major elements of the NEHRP, described earlier in this statement there is a set of program activities and tasks which are the specific responsibility of FEMA to carry out. Consistent with the language from the Act quoted above, it is FEMA s policy and intent to implement these activities within the context of IEMS to the extent possible These activities constitute a FEMA earthquake program of five elements, in addition to the lead agency functions already discussed. The five elements of the FEMA earthquake program are the following:

I. Seismic Design and Construction Standards
II. State and Local Hazards Reduction Programs
III. Federal Response Planning
IV. Mitigation and Multihazard Preparedness Planning
V. Earthquake Education and Information Transfer

Each of these elements will be discussed in turn, both in terms of past accomplishments and planned activities for the future.

I. SEISMIC DESIGN AND CONSTRUCTION STANDARDS

The partial or total collapse of structures resulting from an earthquake is the main cause of earthquake injuries and deaths. However, casualties can occur not only from the buildings themselves but from the secondary effects of failed lifelines, such as fires caused by ruptured natural gas lines. In order to lessen these threats to human life FEMA supports activities which can enhance the seismic safety of new and existing buildings as well as lifelines These activities will result in design standards, practices recommended provisions and manuals for the different users in the construction industry.

This segment of the FEMA earthquake program is being conducted in two parallel, coordinated, and complementary groups of activities. One group is for the use of the private sector, primarily the design professions, the building regulatory entities, and the model code and specification writers. For these users, the FEMA-sponsored end products are intended to be source documents only. The second group of activities is directed at Federal agencies with the two-fold objective of establishing a minimum uniform seismic safety level for Federal construction and setting an earthquake mitigation example on the part of the Federal Government. In both cases, the output of this element of the earthquake program represents the most effective long-range mitigation strategy.

Federal Buildings (New)

The seismic safety requirements for buildings constructed or used by Federal agencies, as well as buildings constructed under various Federal grant, lease, and regulatory programs should be consistent, with different standards, where needed, set to satisfy the special needs of certain mission agencies. To satisfy this objective, the Interagency Committee on Seismic Safety in Construction (ICSSC), representing all Federal construction agencies, was created in 1979 and is chaired by the NBS with funding support from FEMA By January 1981, the ICSSC had formulated and issued a draft seismic standard for new Federal buildings. In issuing the document, FEMA urged Federal agencies to use these provisions in their normal mission-oriented construction activities. The ICSSC has made a recommendation to FEMA on the most suitable process and procedures to ensure a wide acceptance and application of the standard. FEMA is in the process of assessing the policy implications of such a recommendation, which would involve a degree of mandation for Federal agencies. In the meantime, the 1981 standard is being updated and balloted by the Federal agencies.

Non-Federal Buildings (New)

In parallel with these Federal activities are the activities of the Building Seismic Safety Council (BSSC), an independent, consensus, voluntary body established under the auspices of the National Institute of Building Sciences. The BSSC enhances public safety by providing a national forum to foster improved seismic safety provisions for use by the building community in planning, designing, constructing, regulating and using buildings.

Since its establishment just 6 years ago, BSSC, with funding from FEMA, has undertaken a multiyear, multiphased, multiobjective project to: (a) assess the viability and technical validity of (including relevance, clarity, completeness, and practicability), and to refine as necessary, the Applied Technology Council's (ATC) *Tentative Provisions for the Development of Seismic Regulations for Buildings* into a new document; (b) identify societal and regulatory impacts of their implementation; (c) conduct a long-range program to encourage the adaptation of the resource document to local needs by the design professions, the code- and standard-writing organizations, and State and local regulatory bodies; and (d) begin the first of the required periodic updates of this resource document.

The first objective was achieved on schedule with the completion of the trial design of the ATC provisions and the publication of the NEHRP Recommended Provisions for the Development of Seismic Regulations for New Buildings. The trial design process involved almost 50 buildings of different size, shape, occupancy, and construction type in nine cities, six of which are east of the Rockies. The nine cities are Memphis, St. Louis, Charleston, New York, Chicago, Fort Worth, Phoenix, Los Angeles, and Seattle. The results of the process were subjected to a consensus review and then incorporated into the NEHRP Recommended Provisions. These in turn were submitted for balloting by the 57 BSSC member organizations. The technical and philosophical topics raised by balloting are being addressed systematically and a planned second balloting is now scheduled for the fall of 1985 - a few months later than orginally planned. This delay will permit a more deliberate pace in the second balloting and in resolution of issues than was allowed during the first balloting, and foster a consequent strengthening of the consensus process.

Preparation of the manuals on societal implications and on regulatory impacts of the NEHRP Recommended Provisions is proceeding as planned, with the former expected to be ready by May 1985.

During the next phase of the BSSC contract (now being negotiated), a long-range plan will be prepared for encouraging as widespread as possible adaptation or adoption of the provisions by interested users. Complementary documents are also expected to be ready for dissemination by the end of January 1986. In the meantime, NBS is preparing the technical basis for upgrading the provisions, an effort that BSSC is expected to start in the fall of 1985 and pursue in Fiscal Year 1986. This effort will follow a consensus process identical to that used in the development of the first version of the NEHRP Recommended Provisions.

Existing Structures (Federal and Non-Federal)

The activity described so far has been directed at new construction practices however, attention to existing construction is imperative. Spurred by tax credit incentives, the rehabilitation of structures - historical and nonhistorical, residential, and commercial - is proceeding at a rapid pace throughout the country. Most rehabilitation work is done without a set of generally accepted and applied seismic building standards and practices. This means that in areas of high and moderate seismic risk throughout the country, hazardous buildings are being given additional years of occupancy, thus exacerbating an already serious condition.

Yet, there is a considerable body of engineering and architectural knowledge on how to repair and retrofit structures to improve their seismic resistance. Additionally, practical experience resulting from the gradual application of seismic provisions to existing buildings by a few municipalities (e.g., the City of Los Angeles) is being accumulated. There is,therefore, a sufficient base of knowledge upon which to proceed with a comprehensive, multiyear effort to abate the seismic hazards created by old buildings.

For this reason, late last summer FEMA contracted with the newly-formed ABE (Applied Technology Council, Building Seismic Safety Council, and the Earthquake Engineering Research Institute) Joint Venture for the development of a comprehensive and detailed plan for this hazard abatement program. The objective of this plan is to provide FEMA, other Federal agencies, and the private sector with detailed guidelines, a suggested implementation process and identification of the resources required to carry it out. Nine papers have been commissioned and will be the foci of a workshop to be held in Phoenix this month (March 1985) to develop a broad consensus on the plan. The plan itself, based on the commissioned papers and the results of the workshop, is expected to be ready by the end of Fiscal Year 1985. Fiscal Year 1986 funds will be used to start the most urgent and high priority items identified in this plan.

Lifelines (New and Existing)

During this spring (1985), FEMA plans to contract with a broadly-based group similar to BSSC and the ABE Joint Venture to formulate a long-range plan on how to enhance the seismic safety of new and existing lifelines. As in the case of existing buildings, a great deal of activity is taking place, but a coherent, comprehensive plan of action is missing. Its preparation will be even more difficult than that dealing with existing buildings, because of the technical problems involved, the heterogeneity of the different types of lifelines, and the close intertwining of public and private sector roles and activities. The plan is not expected to be ready before the end of Fiscal Year 1986, with implementation, therefore, extending into the out years.

II. STATE AND LOCAL HAZARDS REDUCTION PROGRAM

One of the objectives of the Earthquake Hazards Reduction Act is the following:

> the development, in areas of seismic risk, of improved understanding of, and capability with respect to, earthquake-related issues, including methods of controlling the risks from earthquakes, planning to prevent such risks, disseminating warnings of earthquakes, organizing emergency services, and planning for reconstruction and redevelopment after an earthquake.

To achieve this objective, FEMA is supporting a range of earthquake specific activities in high-to-moderate-hazard States and localities identified by the USGS and FEMA. These activities typically follow a logical sequence of tasks that begins with an assessment of past and potential seismic activity in the area. Based on these assessments vulnerability or loss studies are made to estimate primary and secondary earthquake effects, the number of possible casualties, and potential damage to critical and/or special facilities and lifelines needed for immediate response operations. Using data from these analyses, FEMA assists the State and local governments to undertake preparedness, response, recovery and mitigation planning and to integrate this planning into their overall emergency management programs. Throughout this process, the State and local governments are encouraged to implement public awareness and education programs.

Regarding the vulnerability or loss studies referred to above, the early loss-estimation methodologies were developed for California, where most NEHRP activity was then occurring. With the program's expansion to the rest of the United States, where the nature of the seismic hazards as well as building construction techniques differ from California, it became important that modified loss-estimation methods be developed and better standardized Therefore FEMA plans to develop a more standardized earthquake loss-estimation methodology for use throughout the entire Nation. This methodology will provide a procedure for estimating loss of life, injuries, property damage, and other socioeconomic losses resulting from earthquakes.

FEMA has made significant progress in translating the sequence of activities described above into the tasks and activities that comprise a balanced State or local earthquake hazards reduction program. In 1985, for the first time, Earthquake Preparedness Program Guidelines were included in the Comprehensive Cooperative Agreement (CCA) Guidance Package. (The CCA is the financial/administrative instrument used by FEMA to deliver comprehensive emergency management assistance to State and local governments). Currently we are completing work on a formal Civil Preparedness Guide CPG) for the implementation of earthquake hazards reduction programs by State and local governments It is expected to be available for use in the preparation and planning of Fiscal Year 1986 projects The CPG will provide information on the overall structure and content for earthquake hazard reduction measures at the State and local levels and general information on objectives, funding, government roles and integration with other emergency management efforts. While the CPG is intended primarily for the use of State and local governments, it will contain material that should be of considerable value to FEMA regional staff in their roles of reviewing and approving project applications and monitoring and evaluating the ongoing projects.

Twelve areas of high population/high earthquake risk have been identified by FEMA and the USGS; and in Fiscal Year 1985, for the first time, FEMA is supporting earthquake hazards reduction projects in all of them. The twelve areas are Anchorage, Alaska; Puget Sound, Washington; southern California (Los Angeles and San Diego); northern California (San Francisco Bay Area); Honolulu, Hawaii; Salt Lake City, Utah; Central U.S.; Charleston, South Carolina; Boston, Massachusetts; New York State; Puerto Rico; and the Virgin Islands. These areas are all at various stages of progress in implementing their earthquake hazards reduction programs. Some are at the relatively early stage of vulnerability assessment, such as New York State; while others are involved in preparedness and response planning, such as southern California and Salt Lake City. Mitigation activities are being conducted in California, Puget Sound, and other areas; and Federal response activities, including preparation for exercises this spring, are underway in the Anchorage and Los Angeles areas.

A brief description of the activities in each of the twelve areas follows:

1. Anchorage, Alaska

Alaska has received Federal funding for earthquake planning since the mid-1970's. Completed activities include a loss study for the greater Anchorage area; an earthquake plan for the State and the City of Anchorage; an emergency communications plan for the State; and tsunami safety and flood zone maps. The State also initiated activities to upgrade its emergency power and communication capabilities, and completed a study of the time needed for the restoration of power, gas, and water utilities. Fiscal Year 1984 activities included efforts to evaluate capability shortfalls, conduct a Federal capability analysis, and initiate a Federal preparedness project. Fiscal Year 1985 activities will complete the Federal response preparedness effort.

2. Puget Sound, Washington

Previous work includes a risk assessment and vulnerability analysis completed in 1975, and a preliminary Federal response plan completed in 1981. With Fiscal Year 1981 and Fiscal Year 1982 funds, the State of Washington updated its Natural Disaster Plan, incorporating standard operating procedures for earthquake response by State agencies. In support of this effort, a disaster assistance guidebook for local governments was revised to include earthquake response activities. In Fiscal Year 1983, the State initiated a 5-year effort focusing on local preparedness, response, mitigation, and recovery activities. In Fiscal Year 1984, the objective was to create a disaster medical response capability in the Puget Sound region. Current and future work is projected to continue institutionalizing this capability and integrate it with local emergency management organizations. Also, the development of a set of mitigation strategies for land use and building design is planned.

3. Southern California

A. SCEPP. The Southern California Earthquake Preparedness Project (SCEPP), a cooperative project between FEMA and the State of California, has made the transition over the last year from being a developmental project designed to produce prototypical earthquake preparedness planning tools to the operational, implementation phase. SCEPP is now taking the materials it has developed, and its experience gained in that process, and using both to actively promote earthquake hazard awareness and preparedness throughout its five-county jurisdiction. It should be noted that, in recognition of the shift to an operational/ implementation mode, SCEPP has been transferred from the organizational authority of the California Seismic Safety Commission to that of the Office of Emergency Services (OES). This shift also facilitates the integration of SCEPP's earthquake hazard reduction activities with OES's comprehensive emergency management approach.

B. U.S./Mexico Earthquake Preparedness Project. In December 1983, the Mexico-United States Geological Phenomena Subcommittee of the Mexico-United States Consultative Committee on Natural Disasters proposed a project focussing on earthquake hazard reduction in the San Diego-Tijuana area. A workplan was prepared during Fiscal Year 1984 and work on the project is beginning in earnest this year. The seven major tasks of the project are evaluation of seismic hazard, vulnerability analysis and damage forecasting, emergency response and recovery planning, hazard reduction and mitigation, seismographic networks and information exchange, bilateral coordination, and public information and education. The workplan describes the conduct of these activities for a five-year period (Fiscal Years 1985 - 1989), and currently anticipates completion in Fiscal Year 1989. Implementation is dependent upon the budget appropriations of each nation.

4. Northern California

Fiscal Year 1984 saw the creation of the San Francisco Bay Area Regional Earthquake Preparedness Project (BAREPP), which will implement the workplan developed through the efforts of the previous Bay Area Earthquake Study (BAES) to survey and define current earthquake hazard planning and preparedness needs and priorities. Particular emphasis is being placed on developing and implementing preparedness projects and identifying mitigation opportunities for critical facilities, high-rise structures, and lifelines. This program will benefit from SCEPP's experience and materials and is expected to include similar participation from the public and private sectors.

5. Honolulu, Hawaii

Hawaii has received Federal support for earthquake studies and planning since Fiscal Year 1979, when it received funds to complete a study of earthquake losses in the Honolulu area. With additional funding in Fiscal Year 1981, the State conducted vulnerability studies of critical facilities, lifelines, and other major hazards. Fiscal Year 1982 funds were used to develop planning guidance and begin development of a State earthquake response plan. This plan was completed in Fiscal Year 1984. Current work in Hawaii involves conducting workshops to increase awareness of the plan, preparation for an exercise of the plan, implementation of a public awareness program, and development of statewide mitigation strategies, including seismic building provisions.

6. Salt Lake City, Utah

Early efforts included the preparation of a loss study in 1976, and a Federal response plan in 1978. With Fiscal Year 1981 funds, the State prepared guidance for the development of local response plans for the counties of Salt Lake, Weber, Davis, and Utah. Fiscal Year 1982 funding was provided to Utah to initiate development of operational plans for earthquake preparedness and response in these counties. Subsequent funding was directed toward development of a five-year earthquake preparedness program for the State and completion of the four-county earthquake response plan. Current work is focusing on the detailed integration of the State response plan with those of each of the involved counties, and with all other relevant State agencies. Mutual aid agreements and table-top exercises will be other priorities.

7. Central United States

The central U.S. planning area, defined as the area which would experience damaging intensities from seismic events equal to the New Madrid event of 1811-12, encompasses all or part of 21 States. Severe damages would be expected in seven of those States. These States (Arkansas, Illinois, Indiana, Kentucky, Mississippi Missouri, and Tennessee) formed the Central U.S. Earthquake Consortium (CUSEC) in November 1983. CUSEC was funded by FEMA in Fiscal Year 1984 primarily to coordinate the interstate needs of these States in earthquake hazard reduction. CUSEC's first goal was to integrate each State's independently formulated multiyear earthquake workplan (funded in Fiscal Year 1983) into a comprehensive and coordinated plan for the seven-State area. Current work includes initiation of vulnerability studies for lifelines and critical facilities, identification of medical and mass care needs and delivery mechanisms, and development of a strategy for public awareness.

8. Charleston, South Carolina

The South Carolina "Seismic Safety Consortium" was formed by local initiative late in Fiscal Year 1982. A workshop was held by the Consortium in May 1982 and a white paper on the seismic threat to the southeastern United States with emphasis on South

Carolina was issued. Fiscal Year 1982 funds were provided to complete a task analysis, a needs assessment, and an inventory of existing data required prior to the conduct of the first phase of a vulnerability analysis. The inventory will be completed in Fiscal Year 1985. Preparedness planning will begin in Fiscal Year 1986 and be completed in Fiscal Year 1987. Mitigation planning will be conducted in Fiscal Years 1988 through 1990.

9. Boston, Massachusetts

The eastern Massachusetts risk assessment, completed in Fiscal Year 1984 has provided isoseismal maps detailing high-intensity areas. With the aid of the USGS, a methodology is being developed to assess damage to structures. The establishment of a seismic safety panel for the New England Region is also in the initial stages.

10. New York State

In Fiscal Year 1985 FEMA is funding a planning council to define the specific activities for this area. The council, which consists of representatives across the full societal spectrum, will have its planning affected by such factors as the availability of geotechnical information and the degree of support State and local governmental decisionmakers and others will provide. Vulnerability assessments are also planned to commence in Fiscal Year 1985, preparedness planning in Fiscal Year 1987, and mitigation planning in Fiscal Year 1989.

11. Puerto Rico

In Fiscal Year 1984, Puerto Rico initiated an earthquake vulnerability analysis by examining seismic hazard models from the National Geophysical Data Center in order to select a design event. The analysis is being conducted at the Center for Engineering and Environmental Research (CEER) at the University of Mayaguez. In April 1984, Puerto Rico presented preliminary findings at a FEMA/USGS workshop funded by FEMA. The study is expected to be completed this year. Preparedness planning is scheduled for Fiscal Years 1986 - 1988, and mitigation planning for Fiscal Years 1989 - 1990.

12. Virgin Islands

In Fiscal Year 1983 the Virgin Islands Office of Disaster Preparedness initiated an earthquake hazards planning program. In Fiscal Year 1984, a planning council selected a design event and identified critical facilities on St. Thomas, St. Croix, and St. John. In April 1984, information on the status of the assessment was presented at a FEMA/USGS workshop for which FEMA provided funding support. The vulnerability assessment is expected to be complete this Fiscal Year, with preparedness planning to take place in Fiscal Years 1986 - 1988, and mitigation planning to be conducted in Fiscal Years 1989 - 1990.

III. FEDERAL RESPONSE PLANNING

State and local resources will be inadequate to respond to the effects of a catastrophic earthquake. To save lives and provide for basic human needs, response from the Federal Government, both from the local geographic area and the entire Nation, will be required. Consequently, in recognition of the increasing threat of a catastrophic earthquake in California as well as the possibility of catastrophic earthquakes in other areas of seismic risk throughout the Nation, FEMA initiated in Fiscal Year 1982 a response planning effort that involves the entire Federal Government.

As a mechanism on which to build a base for Federal response to a catastrophic earthquake, the Subcommittee on Federal Earthquake Response Planning was established under the auspices of the Interagency Coordinating Committee. The Subcommittee, formed in August 1982, is chaired by FEMA and now involves 24 Federal and private agencies with identified capabilities and resources to contribute to a disaster response effort.

In Fiscal Year 1984, a third draft of the National Plan for Federal Response to a Catastrophic Earthquake was issued. The plan provides a national-level organizational structure to support Federal regional assistance to State and local governments. In addition to the basic plan, which focuses on policies and assignment of responsibilities, the plan includes 13 annexes which describe emergency support functions required for immediate action to protect lives and property. Including responsibilities assigned to many agencies previously not actively involved in disaster response or assistance, the focus of the plan is on support immediately after a disaster occurs - a period during which the Federal Government usually has only a limited role. The plan creates a framework for Federal response under the provisions of the Disaster Relief Act of 1974 (Public Law 93-288), that is adaptable to any catastrophic event where Federal resources are needed at once to save and protect lives. Though still in draft form, the plan serves as an interim operating guide for Federal agencies to use should a catastrophic earthquake (or other hazard) strike before follow-on regional planning is completed.

The third draft of the National Plan was the focus of a FEMA sponsored two day tabletop exercise named RESPONSE 84, which was based on a simulated catastrophic earthquake on the southern San Andreas Fault. The lessons learned from RESPONSE 84 have now been incorporated into the fourth draft of the National Plan. This revised plan will be tested in exercise RESPONSE 85, scheduled for June 18-20, 1985, in conjunction with the FEMA Region IX (San Francisco) Earthquake Response and Assistance Plan. In this coordinated effort, Federal agency representatives will have the opportunity for the first time to address issues and support that State and local governments would require immediately after an earthquake.

Future work will initiate development of Federal regional plans to support the national Federal response to catastrophic events, and include exercises to maintain and update the National Plan and internal agency procedures.

IV. MITIGATION AND MULTIHAZARD PREPAREDNESS PLANNING

Until now earthquake preparedness planning has been conducted with an exclusive concentration on reducing seismic risk. However, seismically hazardous areas are also prone to other disasters as well. Earthquakes also trigger multiple and simultaneous disasters, such as fires, floods from ruptured dams, landslides and toxic spills. For areas where earthquake recurrence periods are long and current seismicity is low, earthquake preparedness measures may be politically and economically feasible only if combined with those to reduce other hazards.

FEMA is attempting to develop and implement a scientifically sound methodology for comparing and ranking hazards within a geographical area and across some uniform geographical area such as a county. The effort consists of two initial tasks. The first is a literature search to identify the most accurate, useful, and current sources of information on hazard characteristics such as frequency of occurrence and magnitude of consequences. The second task is to determine the feasibility of developing a methodology for cross-hazard analysis and risk assessment using the various hazard characteristics available in existing data bases.

If a cost-effective methodology appears feasible, work would likely proceed on refining the methodology, collecting necessary information, and incorporating the methodology into FEMA's current Hazard Identification, Capability Assessment, and Multi-Year Development Plan process.

Utah Multihazard Project

Another objective of FEMA's is to develop and implement multihazard preparedness planning activities by initiating and supporting prototypical tasks in selected geographic areas. This is a key part of the total program, and its goals and tasks must use similar terminologies and procedures common to earthquake hazard reduction, such as land use, construction standards, preparedness, response, and recovery.

A multihazard approach to planning is underway in the Ogden, Utah area to assess the combined risks from seismic hazards, dam failure, and floods. This prototype activity is expected to provide cost-effective and manageable preparedness strategies and recommendations for short-term mitigation of existing hazards and for long-term land-use planning to avoid them.

Based on these results and other considerations, such as the availability of funds and the strength of local participation, other multihazard planning projects will be conducted. All of these new tasks are expected to be transferable, with appropriate modification, to other high-risk areas. They will focus on urgent problems such as the siting of critical facilities in hazardous geologic and hydrologic zones, and the storage of hazardous materials in structures or disposal sites in flood-prone areas, or in regions of geologic instability.

Banking and Insurance Industries - Mitigation Roles and Seismic Protection.

Because of the critical functions that financial institutions perform in an industrialized society, they need to be examined from two points of view: (1) as agents for bringing about abatement of seismic risks through their loan and related activities; and (2) as institutions, the continuing functioning of which is vital to restoration of community life after a damaging earthquake. FEMA is undertaking a two-pronged effort to examine both aspects of these two industries.

Some preliminary work was done in examining the role of banking and insurance as agents of seismic mitigation when FEMA was first formed in 1979. It has very recently been reviewed and judged to form an adequate basis for further examination. The objective is to reach policy-oriented conclusions as to what feasible mitigation roles can be performed by these two industries and what role, if any, can the public sector perform both at the State and Federal levels. In these investigations, legal and regulatory constraints are undoubtedly significant, so FEMA is at present seeking the advice and analysis of legal experts. The goal is to reach policy conclusions by the end of Fiscal Year 1986.

A private consortium is already planning to examine one aspect of the seismic vulnerability of the banking and insurance industries namely that of data processing facilities, equipment, and personnel. FEMA is considering the feasibility of expanding this analysis to include other significant operational aspects, if any; and joining this private-sector initiative in its analytical and technology transfer activities. A joint role with NSF is under consideration for this expanded examination. Results are expected toward the end of Fiscal Year 1986.

V. EARTHQUAKE EDUCATION AND INFORMATION TRANSFER

The Earthquake Hazards Reduction Act calls for "improved mechanisms ... to translate existing information and research findings into reasonable and usable specifications, criteria and practices so that individuals organizations, and governmental units may make informed decisions and take appropriate actions." In response to this need, FEMA is conducting an active program of earthquake education and information transfer. At the end of Fiscal Year 1984, FEMA completed the development of a multiyear earthquake education management plan. It has had substantial input from Federal, State, and local governments, volunteer agencies civic organizations, educators, and researchers. The plan reflects the contributions of SCEPP and other earthquake projects, FEMA's prototype community outreach projects and pilot courses, and short- and long-term marketing and media campaign strategies Finally, this plan clearly identifies milestones and expected accomplishments to facilitate analysis, evaluation, and identification of future funding priorities.

Community Outreach

This effort facilitates outreach programs through existing State and local public and private safety offices; the American Red Cross (ARC); schools, colleges and universities; community-based organizations; and youth and religious groups to enhance dissemination and use of earthquake education materials.

In August 1983, FEMA awarded funds to support, through Fiscal Year 1986, two pilot Earthquake Education Centers (EECs) - one at the Baptist College in Charleston, South Carolina, and the other at the Tennessee Earthquake Information Center in Memphis, Tennessee. These institutions, which have been monitoring seismic networks, are viewed by the scientific community, State and local emergency managers, the media, and the public as authoritative providers of earthquake information.

EEC activities focus on developing and testing a variety of ways to increase community access to information on earthquake risk and to improve individual and community capability to carry out life-protecting actions during and following an earthquake. Planning approaches include establishing an advisory board composed of community representatives and Region State and local emergency services officials; recruiting and training a cadre of community outreach volunteers; and modifying existing products to address regional seismic risk and to reflect users' language/style and levels of understanding.

In September 1983, FEMA awarded funds to the University of Washington, through the State of Washington, to develop a comprehensive earthquake safety and education program for schools in Seattle. This 3-year pilot project is designed to reduce the vulnerability of the school population to the life-threatening consequences of future earthquakes and to improve students' knowledge and understanding of earthquake causes, effects, hazards, and preparedness measures.

FEMA is also developing strategies to provide earthquake information along with information on other hazards in support of multihazard education programs. To this end, FEMA initiated a series of competitive challenge grants to stimulate local public information demonstration projects; provided a grant to the Children's Television Workshop, producer of TV's Sesame Street, to develop a multihazard program for youth; and initiated a series of emergency information exchanges. This latter activity will bring together ARC, State and local emergency personnel, private industry, and trade groups to stimulate cooperative multihazard awareness efforts and increase capability to deal with citizen information needs.

Information Transfer

This effort is intended to enhance the transfer of hazard reduction information to specific users through workshops and special courses. With USGS, FEMA sponsors workshops designed to increase the hazard awareness of elected officials and influential public and private policymakers in high-risk areas. Since 1981, workshops have been held in Puerto Rico; the Virgin Islands; New York State; Boston, Massachusetts; Knoxville, Tennessee; St. Louis, Missouri; Little Rock, Arkansas; Charleston, South Carolina; and Salt Lake City, Utah. Future workshops are being planned for Puerto Rico, Anchorage, and Los Angeles.

FEMA also sponsors additional conferences to facilitate information transfer. On November 1-3, 1983, the Washington State Department of Emergency Services and the Western States Seismic Policy Council (WSSPC) hosted a National Seismic Policy Conference in Seattle. This conference, supported wholly by a grant from FEMA, was designed to bring together representatives from the States and Territories (about 44) that are subject to high to moderate seismic risk to discuss common problems, exchange information, and promote the adoption of earthquake risk reduction programs throughout the Nation. It represented the first major attempt to disseminate knowledge, techniques, and lessons learned to all States and to transfer project materials from ongoing State projects. As such, the conference paved the way for future strategy planning conferences.

In cooperation with the WSSPC and with funding from FEMA, the Central U.S. Earthquake Consortium conducted a National Earthquake Conference in St. Louis, Missouri, on June 2-5, 1984. The conference focused on (1) the vulnerability of lifelines to seismic events, (2) medical and mass care needs associated with a seismic event, and (3) the role of private industry in earthquake hazards reduction efforts.

Hazard Specific Courses

In Fiscal Year 1982, FEMA provided funds for the first in a series of special topic courses on hazard mitigation. This course, entitled "Earthquake Hazard Mitigation for Utility

Lifelines," is intended to provide city and county public works directors, engineers, utility company and special district officials, and others with information on how to: (1) assess the potential impact of earthquake hazards on utility systems, (2) lessen the effects of ground shaking on critical components of these systems, and (3) develop procedures to hasten system recovery following an earthquake. This course, tested in the San Francisco Bay Area in April 1983 and modified in Fiscal Year 1984, will be deployed as appropriate in the future.

Special courses will be developed in the future to address such topics as earthquake fire hazards in high-rise, high occupancy buildings and non-structural earthquake hazard mitigation for hospitals.

Southern California Earthquake Preparedness Project (SCEPP) Prototypical Materials

SCEPP was designed to produce prototypical earthquake preparedness educat onal and planning materials that would be transferable to other high risk areas of the United States, in addition to its goal of stimulating increased preparedness within the five county region around Los Angeles. In 1984 SCEPP delivered to FEMA the products it had developed since its creation in 1980. These products consisted of comprehensive earthquake preparedness planning guidelines for cities, counties, and corporations; and manuals, brochures, and slide-tape shows designed to provide earthquake planning and preparedness information both technical and non-technical) to a wide range of audiences including local government elected and appointed officials, the general public, the school community (children, teachers, administrators and parents), the disabled, the Spanish-speaking, business and industry, etc. FEMA has reviewed these materials to determine how transferable they are to areas outside of southern California and to determine the most effective means of disseminating them to other areas. We are currently beginning the process of reproducing the materials in appropriate formats, and expect to have them available for distribution later this year. We expect, based upon SCEPP's own research and the comments we received during the review of the products, that the materials will be well accepted for use as models, which will then likely be adapted by various States, agencies, and organizations for their own particular use and audiences. The availability of the SCEPP materials is a major advance in the status of earthquake education and information transfer.

SUMMARY

The intent of this narrative has been to provide an overview of the range of activities that are part of the NEHRP. The programis broad in scope and involves many disciplines: geology, geophysics, seismology, architecture, engineering, law, economics, and the social and behavioral sciences, to name a few. The purpose and goal of the Earthquake Hazards Reduction Act, the reduction of loss of life and property from future earthquakes, can be achieved only with the combined participation and cooperation of private individuals and organizations, business and industry, academia, the scientific community, neighborhood groups, and agencies of local, State and Federal government.

As the preceding narrative has described, much has been accomplished in the years since passage of the Act. Importantly, in many parts of the country, there is a much greater awareness of the hazard posed by earthquakes, as well as a better understanding that it is possible to reduce these hazards.

The progress and accomplishments achieved to date are significant and many; they should not, however, obscure the fact that there is much remaining to be done. More knowledge is needed in the fields of seismology, earthquake prediction, earthquake engineering, and societal response to hazards and disasters. Continued effort is needed to implement the results of research through codes and standards of practice in preparedness, response, recovery, and hazard mitigation, so that the suffering and losses caused by earthquakes can be reduced. FEMA looks forward to its continuing role in this effort.

[The following information was subsequently received for the record:]

QUESTION OF THE CHAIRMAN AND THE ANSWER

Question. In my State of Missouri, we are naturally concerned about the potential for catastrophic earthquakes. Can each of you comment on how your agency has reduced the hazard of a potential earthquake along the new Madrid Fault? What research have you done in this area? And what more should be done under the Earthquake Hazards Reduction Act?

Answer. The Federal Emergency Management Agency's (FEMA) primary efforts in reducing the earthquake hazard along the New Madrid Seismic Zone are aimed at (1) developing increased levels of preparedness, response, and mitigation capabilities within State and local government and in the private sector; and (2) increasing the awareness and knowledge of all sectors of society as to earthquake phenomena and hazards and ways to reduce their adverse consequences. The Central United States Earthquake Preparedness Project (CUSEPP) was established by FEMA to implement these objectives in the central United States.

The New Madrid Seismic Zone is the most seismically active area in this region; therefore the range of its possible effects defines the current area included in CUSEPP. The U.S. Geological Survey has estimated levels of ground shaking which could occur in the central United States from an earthquake event anywhere along the New Madrid Seismic Zone. While 21 States are potentially affected, this delineation of ground shaking intensities clearly shows the States of Arkansas, Illinois, Indiana, Kentucky, Mississippi, Missouri and Tennessee to be the most vulnerable to earthquake damages. CUSEPP, therefore, presently concentrates its efforts in these seven States.

FEMA, through CUSEPP, is providing financial and technical assistance to these States, both individually and as a multistate area. This assistance provides for the following activities:

(a) The identification and estimation of earthquake hazards (ground shaking, landslide, and liquefaction) from the New Madrid Seismic Zone;

(b) The estimation of casualties and losses, based upon hazard identification;

(c) The development of State Seismic Advisory Boards to identify long range planning and task needs, using input from experts in the range of societal and technical fields;

(d) The conduct of conferences and other forums to educate the public about the earthquake hazard and means to address it;

(e) The preparation and dissemination of public awareness/education materials; and

(f) The initiation of preparedness, mitigation, and response planning.

In recognition of the multistate nature of the effects of an earthquake along the New Madrid Seismic Zone, the emergency management agencies of the seven States formed the Central United States Earthquake Consortium (CUSEC). CUSEC addresses the multistate issues inherent in CUSEPP implementation.

This non-profit organization requested FEMA support to conduct its activities and in April 1984, FEMA contracted with CUSEC to (1) establish an operating office with an Executive Director and staff; (2) conduct a national earthquake conference to discuss the issues most important to CUSEC; and (3) develop work plans for FY 85 and FY 86–90 identifying CUSEPP efforts to be carried out by the States and CUSEC. CUSEC is currently funded through November 1985 and its operating office is located in Marion, Illinois. The Executive Director is Mr. E.E. Jones, formerly Emergency Services Director for the State of Illinois.

FEMA's role in the National Earthquake Hazards Reduction Program (NEHRP) does not include the conduct of research activities. However, as explained in my oral and written testimony, FEMA's NEHRP efforts do include activities which utilize research results to provide high risk areas with the technical basis upon which to implement earthquake hazard reduction efforts. An example of this is FEMA's effort to provide seismic resistance standards and criteria for structures. Another example consists of pilot projects in community outreach techniques. One of these is an earthquake education center located in Memphis, Tennessee. These activities demonstrate that most of FEMA's efforts will benefit earthquake hazards reduction not just in individual high risk areas but in other high risk areas throughout the Nation.

Much of FEMA's earthquake hazard reduction efforts must be based upon the collective efforts of each of the NEHRP agencies. FEMA believes, therefore, that the recently completed NEHRP Five-Year Plan represents the best statement of necessary future effort. It should be noted that CUSEC, as part of this overall plan, is tasked with refinement of work plan elements of CUSEPP for FY 86–90. While this plan is currently in draft form, when complete it will identify and prioritize needed tasks for CUSEPP while providing the seven States with a formal means of identifying future earthquake hazard reduction activities.

QUESTIONS OF SENATOR GORTON AND THE ANSWERS

Question. Has FEMA or OMB assessed the impact of choosing funding levels lower than those recommended by the Independent Review Panel (their "B" level)? Will the lower budget levels reduce or slow down the level of preparedness for earthquakes? Has their been any analysis to estimate how much damage or loss of life could result from lower budget levels? If not, why not?

Answer. The principal consideration resulting in the Administration's decision to choose the projected budget levels reflected in the National Earthquake Hazards Reduction Program (HEHRP) Five-Year Plan, Fiscal Years 1985–89 is the overwhelming need to reduce the Federal Budget deficit. Therefore, a quantitative analysis was not undertaken to estimate how much damage or loss of life could result from alternative funding projections.

Within the context of the entire NEHRP, the activities delineated by the five program elements of the Five-Year Plan represent the best combination of activities for the nation as a whole to reduce earthquake induced losses. However, since preparedness planning offers the most immediate short-term payoff to reduce losses, it should be noted that the total budget projection associated with the "State and Local Preparedness Planning" objective of the program element "Preparedness Planning and Hazard Awareness" is actually 40% higher than the estimate provided by the Independent Panel's Level B Plan. This is a recognition by the Federal Emergency Management Agency of the fundamental and inherent role that State and local governments play in preparedness planning for all hazards, including earthquakes. When this increase is balanced against the projections for the other five objectives comprising the "Preparedness Planning and Hazard Awareness" program element, the nation's capability to prepare for the earthquake threat will be minimally affected. However, the net impact resulting from the Five-Year Plan's lower total budget projection for the five year period will result in the entire range of activities identified in the other four program elements of the Plan being accomplished at a slower rate when compared to the Independent Panel's Level B budget estimate. It is FEMA's view that the emphasis placed on State and local preparedness planning will have the effect of reducing the loss of life and property destruction when a serious earthquake occurs.

Question. A recommendation of the Independent Review Panel that was not incorporated into the 5-Year Plan was that there be a small fund set aside for post-disaster investigations. Were there ample funds available for investigating the Chilean earthquake? If so, where did these funds come from?

Answer. There were sufficient funds to assemble and send a multidisciplinary team to assess the damages of the Chilean earthquake. The team was sponsored jointly by the Earthquake Engineering Research Institute (EERI) and the Committee on Natural Disasters of the National Research Council, National Academy of Science. The team consisted of 12 experts headed by Mr. Loring Wyllie of the firm of H.J. Degenkolb Associates of San Francisco. This portion of EERI's activities is funded by the National Science Foundation (NSF); the Academy Committee is funded jointly by the Foundation Oceanic and Atmospheric Administration, the Federal Emergency Management Agency and NSF.

Question. Have any preparedness plans or vulnerability studies considered the possibility of earthquakes causing chemical plants to fail and causing a Bhopal-type of accident?

Answer. The possibility of earthquakes causing chemical plants to fail is addressed in several ways in the earthquake vulnerability studies and preparedness plans supported by the Federal Emergency Management Agency (FEMA). This type of situation is best covered by FEMA's Integrated Emergency Management System (IEMS). IEMS identifies the functional elements of emergency management that are common to the full range of both natural and technological hazards.

These functional elements fall into the categories of mitigation, preparedness, response and recovery. Some of these functional elements are direction and control, emergency communications and warning, population protection, hazard analysis and mitigation, and public information and emergency education. The IEMS process for any particular jurisdiction involves an initial hazard identification, vulnerability assessment, capability assessment, and a multiyear planning process to improve emergency management capabilities.

In the case of an earthquake causing the failure of a chemical plant, the hazard identification process would describe the earthquake threat to the particular area. The susceptibility of any chemical plants (or other potentially hazardous facilities) to earthquake caused damage or failure would be identified during the vulnerability assessment. In addition, when the primary hazard of chemical spills or releases is being considered by the emergency management authorities of a given locality, they should consider the occurrence of these incidents as the result of an earthquake. FEMA's Planning Guide and Checklist for Hazardous Materials Contingency Plans, designed to assist State and local officials to develop such plans, addresses the need for planning for hazardous materials incidents that result from damage caused by earthquakes and other natural hazards. The document also encourages officials to pay particular attention to those facilities that are located in areas vulnerable to earthquakes.

The preceding describes the management of earthquake caused failure of chemical plants by the appropriate units of government (generally State and local). An incident that is beyond the capability of a State to deal with would most likely result in a request for Federal assistance. It must be recognized that a substantial area of responsibility lies within the private sector as well. Owners and operators of chemical plants must be cognizant of the range of hazards these facilities are subject to; earthquakes are but one of several.

In the absence of Federal or State regulation of these plants relative to multihazard preparedness, response and mitigation planning, the strategy FEMA uses to prevent or mitigate such events is to strongly encourage cooperation, communication, and mutual planning between the owners and operators of such facilities and the emergency management officials of the appropriate local or State governments. In the Central United States, the Dupont company is involved in the earthquake preparedness activities of Memphis, Tennessee, and has established ties with the Tennessee Seismic Advisory Panel. In St. Louis, Missouri, Monsanto has become involved in the earthquake preparedness effort. In California, the existence of the Business and Industry Council for Earthquake Preparedness attests to the commitment of private corporations to earthquake preparedness. Also, the current Chairman of the Policy Advisory Board of the Southern California Earthquake Preparedness Project (SCEPP) is an official of the Atlantic Richfield Company. While not a chemical company per se, it is a company the facilities of which could be seriously damaged by an earthquake and cause significant harm to both people and the environment. Its involvement with SCEPP is an example of the public-private partnership that FEMA considers essential to the management of the type of incidents referred to in your question.

Question. Our review of FEMA's National Plan for Federal Response to a Catastrophic Earthquake (Draft Number Four) raised concerns about several aspects of the plan.

Answer. A general statement about the National Plan and its intended purpose is necessary before we address the specific questions raised. Draft Number Four of the National Plan represents the collective efforts of FEMA and 23 other Federal agencies and is one of the major milestones in an interagency planning and exercising effort which began in early 1983. A Washington-area tabletop exercise, named RESPONSE 84, was held in August 1984. Some of the "lessons learned" from the exercise have been incorporated into Draft Four; other lessons need to be further explored in conjunction with regional planning efforts.

The National Plan is primarily concerned with life-saving and life-protecting functions and the national level support to regional Federal agency operations as they support State and local efforts during emergency operations, under the provisions of PL 93-288, the Disaster Relief Act of 1974. A primary agency and support agencies have been identified for specific functions so that additional planning can be carried out in site-specific earthquake risk areas to ensure availability of Federal resources when required in an immediate response environment a a result of a Presidential major disaster declaration.

The specific emergency support function groups (ESFG) represents FEMA's authority and responsibility to task other Federal agencies; through the national-level planning effort and follow-on regional planning, these agencies are better prepared to perform "mission assignments" during emergency response. In addition to the ESFGs, the National Plan establishes the Catastrophic Disaster Response Group (CDRG) as a forum for representatives of all Federal agencies to meet, discuss, and coordinate national level concerns and support other impacted area. A FEMA official chairs the CDRG to fulfill FEMA's responsibilites as the lead agency for coordination under E.O. 12148.

Region VIII (Denver), Region IX (San Francisco), and Region X (Seattle) also have developed earthquake response plans with their Federal agency counterparts for specific earthquake risk areas in their regions. The FEMA Region IX Earthquake Response and Assistance Plan identifies those specific functions intended to support response to a catastrophic earthquake in California.

The National Plan and the Region IX Plan will be tested in a major exercise, names RESPONSE 85, scheduled for June 18-20, 1985. A summary sheet discussing the scope, purpose, and objectives of RESPONSE 85 is attached for information. This exercise is the first in a series of coordinated exercises intended to improve the ability of all levels of government to respond to the efforts of a catastrophic earthquake. The results of RESPONSE 85 will be documented in an after-action report and will form the basis for continuing and improving Federal response plans.

Question. We found only one brief reference in the plan to the dissemination of public information. Is this adequate in view of the fact that getting reliable information to the public has been a major problem in many disasters?

Answer. Public information was not specifically addressed in the National Plan because release of public information is a coordinated effort that needs to be developed for purposes of all disasters, to support all levels of government in the disaster area. Efforts independent of the interagency National Plan (which has as its focus the specific resources and national assistance required to support regional operations) are underway to improve dissemination of information to the public. One such effort is development of a Joint Information Center (JIC) concept and system, which uses a catastrophic earthquake event as the basis of its design, but it is intended for use in any major disaster.

The Region IX response plan includes an annex on public information, which will be evaluated during RESPONSE 85. Staff in Region IX have been involved in development of the JIC concept and will incorporate this effort into revisions to the Region IX plan.

Question. We were unable to determine how decisions would be made in the event of a catastrophic earthquake. Does the Director of FEMA or the chairman of the CDRG make decisions at the national level? Or are decision made by Committee vote? Are any decisions made at the ESFG level, and if so, by whom? Who has the authority to allocate constrained resources at the regional level? How could national security considerations change the decision-making? What are the reporting methods for passing vital information to the decision-makers?

Answer. Requests for State assistance will be made to the FCO who will identify the appropriate Federal agency authority to address the need and coordinate the delivery of assistance. If the authority and resources to meet the State request are within existing authorities of another Federal agency, the FCO will direct the request to that agency. If no other Federal agency has existing authority and resources, the request will be directed to the FEMA Regional Director who has delegated authority under P.L. 93-288 to task and reimburse other Federal agencies to provide the disaster assistance.

The plan is constructed in functional areas and pre-assignments are made to Federal agencies at both the regional and national levels to carry out requests from the State for assistance within these functional areas. Decisions to allocate resources to meet the State requests within each of the functional areas are the responsibility of the regional primary agency of the functional assignment as supported by the appropriate national level ESFG when resource needs exceed the regional supply. When State requests place demands for resources that exceed those available within given functional areas, the FCO will make decisons in consultation with the State Coordinating Officer on prioritization of Federal resource allocations. The FCO will report these decisions to the Chairman of the CDRG who will direct the other Federal agencies' resources on a nation-wide basis.

The FCO reports to the FEMA Associate Director, State and Local Programs and support, who is also the Chairman of the CDRG. The FEMA Associate Director, SLPS, reports to the FEMA Director who reports to the President Decisions for providing assistance under P.L. 93-288 are vested in FEMA. The authority to coordinate P.L. 93-288 and other Federal agency authorities and activities to meet disaster needs is vested in FEMA through the appointed FCO, who is on-scene, and supported at the National Headquarters policy making level by the FEMA Associate Director, SLPS. The operational decision making responsibilities are vested in the senior field officials. The policy making decision responsibilities are vested in the FEMA Associate Director, SLPS, as supported by the other senior Federal agency representatives of the CDRG.

Concerns for national security are being addressed outside of the scope of the National Plan for Federal Response to a Catastrophic Earthquake by the Department of Defense and others. These agency representatives to the CDRG are responsible for informing the CDRG of national security concerns, and would also provide the link to the appropriate officials addressing the issue. One particular area being addressed by DOD involves preparedness of defense contractors; RECOVERY 85 is being conducted as a parallel effort to RESPONSE 85. FEMA project staff work closely with DOD to coordinate these parallel efforts.

Supplemental plans and procedures are being developed to support the overall response structures defined in the National Plan and the Region IX plan, and will be evaluated as one of the mutual objectives during RESPONSE 85.

Question. The National and regional response structure was also unclear to us. Is the Federal Coordinating Officer directly responsible to the Director of FEMA? Do the headquarters elements of the responding Federal agencies take their orders from their respective representatives on the CDRG? How are independent response actions of these agencies authorized and coordinated?

Answer. As indicated above, the FCO is responsible to the Associate Director, State and Local Programs and Support, FEMA, who in turn is responsible to the Director, FEMA, and in turn, to the President. The CDRG representatives provide the centralized, coordinating body that is aware of the entire response effort and serves as a mechanism to bring to bear all Federal resources, capabilities, and responsibilities that can contribute to an enhanced Federal response capability. They serve as a conduit to the activities of their own agencies independent of the authorities and responsibilities assigned to them under the Disaster Relief Act; in some cases, the agencies would be responding to "orders" at the request of their CDRG counterparts or because the information provided to them prompts some action.

RESPONSE 85 is expected to provide an opportunity to evaluate the overall Federal response structure and the improvements to be incorporated into future planning efforts.

Question. Is the plan organized in a way that it can be used off-the-shelf? Please explain.

Answer. An important part of the plan is the response support structure that is established to bring together Federal agency representatives; this structure can be put into place by maintaining the notification and activation procedures which will be updated periodically. Even in draft form, the plan can be use do form the basis for response in areas where follow-on regional planning has not been completed.

In addition to a catastrophic earthquake, the National Plan is intended to support response to any major event which would require Federal assistance during emergency life-saving and protecting operations. The results of RESPONSE 85 will be incorporated into a final version of the National Plan, and will contribute to follow-on regional response planning. This effort will ensure that the Federal agency representatives responsible for response planning maintain an active involvement.

Question. Has the plan been independently reviewed? Will it be?

Answer. On March 4, 1983 a notice was published in the Federal Register which outlined the emergency support functions, policies, planning assumptions, etc., that formed the basis of the National Plan. This has been the only opportunity to date that the public has had to review and comment; however, officials of the Federal agencies involved in the planning effort have had the opportunity to review each draft of the National Plan.

All those who participate in RESPONSE 85 will have the opportunity to provide comments and contribute to and improve National Plan. A final draft of the plan is scheduled to be published in the Federal Register by March 31, 1986 for review and comment: this will provide an opportunity for interested parties to review the Plan prior to final publication, presently scheduled for June 30, 1986.

EARTHQUAKE EXERCISE RESPONSE 85

SUMMARY PAPER

I. INTRODUCTION

A. General. RESPONSE 85 is a disaster simulation exercise involving State, local, regional and national response to a major earthquake on the southern San Andreas Fault in California. Earthquake response plans for such an event have been developed by various levels of government. While many of these plans have been independently exercised, RESPONSE 85 is the first major exercise testing such plans in an interactive environment. The exercise will take place June 18-20, with exercise play concentrated in the FEMA Region IX offices at the Presidio of San Francisco and at Federal agency offices in Washington, D.C. The scenario for RESPONSE 85 begins on the second day following a catastrophic earthquake, and builds upon actions taken during a State and local exercise conducted April 18, 1985. This earlier exercise addressed State and local response during the first 24 hours after an earthquake.

B. Background. Over the past 10 years, the Federal Government has assessed the vulnerability of selected high-risk, high-population areas of the United States to a catastrophic earthquake. The increasing probability of a catastrophic earthquake in California during the next two or three decades, and the low probability but high damage potential of a similar earthquake in other areas of the nation, has caused State and Federal officials concern that response plans and preparedness measures may be inadequate to cope with the impact that would result from a catastrophic earthquake. To rectify the situation, the Federal Government has developed a National Plan for Federal Response to a Catastrophic Earthquake representing the collective efforts of 24 Federal departments and agencies. The FEMA Region IX Earthquake Response and Assistance Plan is the first comprehensive site-specific regional plan linking Federal response and assistance to State and local planning efforts.

II. PURPOSE AND OBJECTIVES

A. Purpose. The purpose of RESPONSE 85 is to evaluate Federal earthquake response planning and to improve the capability of all levels of government to respond to a catastrophic earthquake event. RESPONSE 85 provides an environment that will realistically simulate interface of Federal actions with State and local efforts. The specific focus of the exercise is to evaluate the adequacy of national and regional draft response plans to support saving and protection of lives and property and provision of basic human needs.

B. Mutual State-Federal Objectives. The following summarizes exercise objectives mutually agreed upon by the State of California and the Federal Emergency Management Agency:

- Identify issues, policies, and requirements which must be addressed to enhance overall preparedness.
- Exercise procedures for utilization of resources external to the affected region.
- Extend awareness, experience and training to a wider segment of the earthquake response community.
- Increase the familiarity of senior government decisionmakers with earthquake response issues.
- To evaluate the adequacy of supporting telecommunications and information systems plans.

C. National Objectives. In addition to the above objectives, the following are those primary objectives selected by the Federal interagency exercise planners for emphasis and evaluation at the national level:

- Exercise and evaluate the effectiveness of the response structure detailed in the National Plan.

- Determine the adequacy of Washington-area communications and information systems to support operational requirements.

- Assess the effectiveness of national-level elements to obtain, allocate and arbitrate demands for critically needed resources.

D. Regional Objectives. From the regional perspective, the major objectives of exercise RESPONSE 85 are:

- To determine the adequacy and feasibility of the Region IX Response Plan for ensuring effective, coordinated, and responsive Federal support to simulated State and local response efforts.

- Identify issues, problem areas, requirements, policies, etc., which must be resolved or considered for change to improve the overall Federal response effort.

- Provide experience and training under simulated conditions to Region IX and other Federal agency personnel.

- Familiarize senior decisionmakers with the Federal response mechanism established by the National Plan and the Region IX Response Plan.
- Identify the essential elements of information needed by FEMA Region IX and other Federal agencies to support their immediate and ongoing functions and activities in a catastrophic earthquake situation.

- Determine the need for additional supplemental plans or procedures to support the Region IX Response Plan.

E. Additional Opportunities. In addition to meeting the objectives listed above, RESPONSE 85 will provide a unique opportunity for participation of officials from a wide range of government and private agencies. While the exercise will focus on disaster response issues, specifically saving and protection of lives and property and provision of basic human needs, it wil also serve as an opportunity to consider broader issues involving national welfare, economy and defense. The latter issues will be evaluated independently by appropriate departments and agencies.

III. EXERCISE DESIGN.

A. Concept. RESPONSE 85 is a "no-fault" exercise designed to evaluate the adequacy and integration of response plans, procedures organizational structure and supporting systems, and not the performance of individual exercise players. As an element of an evolutionary series of preparedness exercises, RESPONSE 85 further explores issues which emerged during RESPONSE 84, a Washington-area "table-top" exercise conducted last year to refine the National Plan. Play begins on the "second day" following the earthquake event; "first day" activities were simulated in a State-local exercise conducted on April 18, 1985. The input from State and local officials throughout the design and planning for RESPONSE 85 has added otherwise unobtainable realism to the exercise scenario.

B. Planning. The Exercise Executive Committee responsible for the overall planning, control and evaluation of the exercise is comprised of the Exercise Director, Dave McLoughlin, FEMA's Deputy Associate Director for State and Local Programs and Support, and Assistant Directors representing national, Hugh Richardson, regional, Terrence Meade Region IX, and State, Jack Kearns, California OES. activities   Each of the three Assistant Directors leads an Exercise Planning Group responsible for developing specific objectives, issues and events related to their respective governmental level.

C. Timeframe. Exercise play for RESPONSE 85 takes place on June 18-20, 1985. Although response to a real-world catastrophic earthquake would entail 24-hour operations, exercise play has been administratively broken into 8-hour periods. The three daily exercise periods simulate a continuous time period on the exercise clock, representing the second day of activities (from +24 to +48 hours) after the earthquake event. Exercise play will be followed by a critique on June 21 1985.

D. Scenario. The exercise scenario depicts a catastrophic event which paralyzes the lifelines in and around the greater Los Angeles area. The description of the disaster event was prepared by the State of California, with input from local officials. The scenario is based on an earthquake measuring 8.3 on the Richter scale which occurs on the southern San Andreas Fault. It will be assumed that casualties and damages from such an earthquake exceed the response capabilities of the State, will require the immediate implementation of Federal, regional and national plans, and will result in a Presidential Major Disaster Declaration within two hours.

IV. EXERCISE PLAY

A. Player Participation. Player participation in RESPONSE 85 has been encouraged from national and regional Federal agencies identified in the National and Region IX earthquake response plans. The State of California and selected county officials will form response elements to provide realistic interaction with the Federal community. "Real-world" systems and procedures will be tested as an integral part of this exercise; personnel at communications and operations centers of participating agencies have been requested to receive and disseminate simulated event messages according to agency procedures.

Although players are expected to respond to situations presented during the exercise in accordance with the provisions of their agency's plans, situations presented to the participants will require considerable individual initiative and have been constructed to stimulate "free play" exchange and surface unanticipated issues. Key players include the Federal Coordinating Officer (FCO); FEMA Region IX Director; and the State Coordinating Officer (SCO), appointed by the Governor of California.

B. Exercise Control. RESPONSE 85 exercise play will be guided by pre-scripted event items contained within a Master Scenario Events List (MSEL). RESPONSE 85 MSEL items are tailored to reflect the outcomes and issues surfaced from the April 18 State and local exercise. During actual exercise play, members of the Federal, regional and State-level Exercise Planning Groups will serve as exercise controllers and data collectors. Controllers manage the tempo of the exercise, deliver verbal and written MSEL items announcing simulated events, coordinate adjustments in such injects to compensate for player actions, and provide realistic response to player-initiated communications Controllers provide realistic portrayal of individuals and organizations that are not participating in the exercise but whose input is necesary for exercise play, such as members of the State legislature and Congress, private citizens, business and industry, and the press.

V. AFTER-ACTION REPORT

An after-action report will be prepared and will contain an analysis of exercise results as they relate to the stated objectives of the exercise The report will include observations, conclusions and recommendations regarding relevant issues surfaced during exercise play, and identification of shortfalls and deficiencies in response plan policies procedures and supporting systems. The after-action report will provide a basis for improved Federal planning and continued interaction at all levels to prepare for enhanced response to a catastrophic earthquake.

QUESTIONS OF SENATOR GORE AND THE ANSWERS

Question. A considerable amount of money has been spent by the earthquake program since it was created in 1977. Expenditures this year will total $70 million.

What have the American people gotten in return for the investment? How much progress have we made towards predicting earthquakes, mitigating the hazards, and preparing to respond when a major earthquake strikes?

Answer. One of the basic tenets of the National Earthquake Hazard Reduction Act (P.L. 95–124) and its subsequent amendments was to bring together the ongoing programs of the United States Geological Survey (USGS), National Science Foundation (NSF), National Bureau of Standards (NBS) and the Federal Emergency Management Agency (FEMA) into an integrated, comprehensive and multi-disciplinary national program of earthquake hazard reduction. Since 1977 the integrated framework established by the Act, along with sufficient funding, has allowed the Federal Government to make substantial progress in addressing the nation's earthquake hazard. This process is documented yearly through the submission by the President of an annual report to the Congress on the National Earthquake Hazards Reduction Program (NEHRP) as required by Section 6 of P.L. 95–124. These annual report submissions, the most recent one being for Fiscal Year 1984 and transmitted to the Congress by FEMA in December 1984, provide for a comprehensive accounting of the progress being made by the Federal agencies in fulfilling their responsibilities in all activities authorized under the NEHRP including earthquake prediction, mitigation and response planning. Therefore, the detailed documentation included in the annual reports should be considered integral to this reponse.

A few of the more significant accomplishments since passage of the Earthquake Hazards Reduction Act are:

There is a much clearer understanding about the nature of earthquake fault mechanisms in different parts of the country.

From historical and geological data, much has been learned about earthquake recurrence on faults in the United States. Methods are being developed for making probabilistic assessments of times of increased seismic hazard on a particular fault, a step important to the eventual prediction of earthquakes.

A new generation of maps of ground shaking has been prepared for the entire United States, providing a much better basis for seismic zoning and building codes and for assessing earthquake hazards.

The understanding of potentially destructive earthquake motions has been significantly advanced by the measurement of ground motions and structural response obtained during the Imperial County, California, earthquake of 1983.

State level earthquake hazard reduction programs, which include mitigation and response planning components, are underway in all of the major or moderate risk areas originally indentified by P.L. 95–124.

Detailed earthquake loss estimates have been completed for several metropolitan areas, providing a basis for better preparedness planning; additional studies are underway for other communities.

A "National Plan for Federal Response to a Catastrophic Earthquake" involving 24 Federal and private agencies has been developed.

New and improved seismic standards and building-code provisions are being prepared for consideration by Federal, State, and local governments. The American Association of State Highway and Transportation Officials adopted improved seismic procedures for highway bridges for national application.

Improved methods of dynamic analysis are now routinely used to achieve safe, yet economical designs of special structures. These include dams, power plants, offshore structures, and other facilities.

Hundreds of professionals, primarily engineers and geoscientists, have been educated and trained with the support of the Act's research program.

There has been an expanded program of information dissemination to engineers and other practicing professionals, local officials, and the public. Workshops have been sponsored in different parts of the country, bringing together businessmen, local leaders, government officials, and scientists to identify steps that can be taken to reduce the earthquake hazards in their regions. This augmented the traditional ways (publications and meetings) that research results are transmitted.

The Southern California Earthquake Preparedness Project (SCEPP), a joint State and Federal effort, has brought together many diverse local groups to identify and implement measures to reduce anticipated losses during future earthquakes and to prepare for possible predictions. This project serves as a model for efforts in other areas.

Moreover, in many parts of the country, there is a much greater awareness of the hazard posed by earthquakes, and a better understanding that it is possible to reduce the hazards. This awareness has assisted, for example, in the enactment by the City of Los Angeles of a hazardous buildings ordinance.

Question. FEMA's FY 1986 budget request includes a decrease of $1,000,000 in Emergency Management Planning and Assistance.

What is the reason for this cut? What effect will it have on your activities? What effect will it have on the ability of States and localities to prepare for earthquake?

Answer. In keeping with the efforts to reduce the Federal Budget deficit, the Administration proposes reducing by one-half the increase FEMA received in 1984 for the earthquake program. The rationale being that since none of the other primary agencies involved in the National Earthquake Hazards Reduction Program (NEHRP) received increases this reduction will rebalance this program to those in the other agencies and to staff available to manage the program. FEMA's earthquake program activities as reflected in the five-year plan are multi-year efforts. The effect of the proposed decrease will be a general overall reduction in the level of effort and funding designated for FEMA's projects, thereby extending the period of time required to complete tasks. Since FEMA will have initiated State and local preparedness planning activities in the 12 identified areas of major or moderate risk, the effect of the proposed decrease will be a slowing down of State and local efforts as these areas proceed through the earthquake preparedness planning process. Ongoing projects will continue but at reduced funding levels. The ability of States and locals to prepare for and respond to potential earthquakes will be somewhat restricted. Concurrently any initiatives to extend preparedness planning activities to contiguous earthquake prone areas will not be undertaken.

Question. Your FY 1986 Budget request includes a cut in spending but an increase in "workyears" for the program. Will you explain how you are cutting your budget but increasing the number of personnel?

Answer. The increase of 13 workyears to the earthquake program is not an actual increase but rather the formal transfer of funding responsibility for these encumbered workyears from the flood plain management program to the earthquake program. This transfer is being undertaken to more accurately reflect workyear usage in FEMA. As FEMA's responsibilities under the National Earthquake Hazards Reduction Program (NEHRP) increased, additional workyear resources were applied both formally and informally to accomplish program objectives. In FEMA's FY 1986 Budget, these resources previously funded under flood plain management are identified as necessary to support the earthquake program. Therefore, a formal request for transfer of these positions is being effected through the budget process. The 25 workyears requested represent the commensurate level of resources needed to sustain FEMA's responsibilities under the NEHRP.

Question. You support vulnerability analyses and preparedness and mitigation planning activities in a number of high-risk areas. What is FEMA's role in these analyses and activities? What specific actions do you take? What end-products result from this process? How do these products help State and local officials mitigate earthquake hazards?

Answer. FEMA, in fulfilling its responsibility to generate a reduction of earthquake hazards in high-risk areas, supports a range of activities at the State and local level. These activities include earthquake hazard identification, vulnerability assessment based on the hazard identification, preparedness and mitigation planning and implementation, and public awareness/education efforts. Support for these activities in State and local areas is effected through financial and technical assistance.

FEMA's role in vulnerability analyses is to fund actual study work. Normally the funds are to the State for work performance by a State agency or a contractor. FEMA suggests methodologies to be applied and assists the State in development of the scope of work. While the study is ongoing, FEMA monitors progress to ensure effective expenditure of effort. The end product will be a study which discusses the impacts of a selected earthquake scenario in terms of estimates of building losses, casualties, and lifeline systems availability. Such information allows officials of high-risk areas to identify needed preparedness measures and overall scope of relief efforts. The study can also underscore particularly vulnerable lifelines systems or building types and thereby allow for the initial identification of mitigation priorities.

In preparedness planning activities, FEMA again directly funds the State and/or local area to prepare the necessary annexes to existing jurisdictional Emergency Operations Plans. These plans address the response needs, particular to the earthquake hazard, that have been identified through the earthquake vulnerability assessment.

It is also FEMA's role to act as the coordinator and provider of relevant technical assistance materials developed within the emergency management and earthquake hazard reduction communities. The end products of the preparedness planning process are implementable response plan annexes developed for a specific jurisdiction's plan. These plans are then tested and maintained through exercising.

As part of the preparedness planning process FEMA provides funding assistance to State and local governments for the identification of mitigation needs, priorities and strategies. Once mitigation opportunities are identified, FEMA supports workshops and development of specific materials for educating appropriate sectors (e.g. architects, engineers) in mitigation techniques. A critical component of this is the development and provision of technical assistance materials relative to seismic considerations in buildings and lifeline systems.

These activities, and the others mentioned previously, are undertaken by the State and local areas with FEMA funds. This assures that the States are integrally involved in all phases of earthquake hazard reduction. Therefore, while FEMA monitors and tracks progress and provides guidance, so that efforts are nationally consistent, the end products are State generated and not viewed as Federally imposed: this aspect is an important part of the "partnership" attitude in earthquake hazards reduction.

Question. Next June, you will hold an exercise called RESPONSE 85 to test existing response plans. What will the exercise involve? What do you hope to learn from it?

Answer. RESPONSE 85 will be the first exercise in an evolutionary series of coordinated Federal, State and local exercises intended to improve the collective preparedness of all levels of government to respond to a catastrophic earthquake. The overall purpose of RESPONSE 85 is to exercise Federal earthquake response plans including the fourth draft of the National Plan for Federal Response to a Catastrophic Earthquake, dated March 22, 1985, and the FEMA Region IX Earthquake Response and Assistance Plan, dated May 1, 1984, to determine the adequacy of those plans to support lifesaving and life and property protection efforts.

RESPONSE 85 will build on the experiences of the California State and local exercise scheduled for April 18, 1985. FEMA Region IX and other regional Federal agencies will participate in a limited deployment capacity and as observers. Federal agencies at the national level will receive the simulated earthquake event notification, initiate selected procedures, gather relative data, and begin assessment of Federal assistance requirements. The April 18 exercise will be considered Day 1 of exercise RESPONSE 85.

Exercise RESPONSE 85 will occur June 18–20, 1985, to be followed by a critique June 21, 1985. The exercise is a disaster simulation exercise involving local, State, regional and national response to a major earthquake on the southern San Andreas Fault in California. Twenty-three Federal agencies, together with their regional counterparts, as well as volunteer agencies and the State of California Office of Emergency Services, other primary State agencies and affected counties will participate in RESPONSE 85.

Through RESPONSE 85 we hope to learn:

How effectives the National Plan response structure is in satisfying regional and State support requirements;

The adequacy of Washington-area communication's and information systems to support effective interaction and information exchange among Federal agencies and the regional offices;

The adequacy of telecommunication plans to satisfy national-regional interaction in support of State requirements;

The effectiveness of coordination of national-level response support efforts; as well as the effectiveness of the national-level response structure to obtain, allocate, and arbitrate demands for critically needed resources;

The adequacy of procedures for providing public information release and for handling congressional inquiries;

The adequacy of the administration and facility support provided to the interagency coordinating groups.

RESPONSE 85 is a follow-on to a previous exercise conducted last year, RESPONSE 84. The lessions learned during RESPONSE 84 were incorporated into the current draft national and regional plans which will be tested in RESPONSE 85. After June 21, 1985, each governmental level will prepare an evaluation or after-action report which focuses on the specific objectives and issues of interest to senior officials at those levels. These after-action reports will be used to finalize planning documents and in the conduct of future exercises.

Question. In FEMA's judgment, which specific Federal activities, or combination of activities, offer the most promise for reducing loss of life and property due to earthquakes?

Answer. Within the context of the entire National Earthquake Hazards Reduction Program (NEHRP), the activities delineated in the 5-Year Plan for the NEHRP represent the best combination of activities required to reduce earthquake induced losses. These activities are explained in more detail in pages 4-7 of my testimony submitted for the record March 19, 1985, to the Subcommittee. It is FEMA's view that each of the activities planned by the agencies of the NEHRP are inter-dependent.

Earthquake losses will be reduced, in the final analysis, by the effective implementation of preparedness planning and mitigation measures by the Federal, State, local, and private sectors. Preparedness planning is the effort with the short-term payoff to reduce losses through planning to respond knowledgeably to an area's vulnerability to earthquakes. Mitigation has the long-term payoff in reducing that overall vulnerability.

Senator GORTON. Dr. Speck, I thank you. I believe we will hear from the entire panel, and engage in questioning then. So we will go to Dr. Peck.

Dr. Peck, your entire statement will be included in the record.

Dr. PECK. Thank you, Mr. Chairman.

As Director of the U.S. Geological Survey, I am pleased to testify at the hearings on reauthorization of the National Earthquake Hazards Reduction Program.

As you have permitted, I shall submit my testimony for the record and make a few brief comments. I will be happy to answer any questions you might have for me.

Toward this end, I am accompanied by Dr. John Filson, Chief of our Office of Earthquakes, Volcanoes, and Engineering.

About 100 years ago, on September 1, 1886, John Wesley Powell, the Director of the Geological Survey, sent J.W. McGee to Charleston, SC, to examine the effects of a large earthquake that had occurred near Charleston the previous day.

Today, the Geological Survey continues to maintain its commitment to the study and reduction of earthquake hazards under the aegis of the Earthquake Hazards Reduction Act.

With proposed funding of over $34 million in fiscal year 1986, our earthquake studies represent the largest single program in the budget of the geologic division of the USGS. There are over 400 employees in the Survey working on earthquake research or related activities. About half of these are scientists and engineers.

During our current fiscal year, we have a total of 110 contracts with universities, State agencies, and private forums for studies that complement and extend the work done within the Survey. About a quarter of our annual appropriation is used to support these contracts.

The Survey maintains research and data analysis facilities in Menlo Park and Pasadena, CA, and Golden, CO, to carry out work related to the Earthquake Program. Our research primarily addresses problems in earthquake hazards assessments, earthquake prediction, long-term earthquake potential, and engineering seismology.

We provide 24-hour monitoring of national and worldwide seismicity and other services through our national earthquake information center. We support, in some cases with other Federal agencies, the operation of regional seismic networks in several western

States, the central Mississippi Valley, and the northeastern United States.

These networks are used to monitor the current seismicity of the country, to identify active geologic structures, and to assess future earthquake hazards. We maintain the national strong motion network to provide data on strong earthquake shaking for engineering design purposes.

For earthquake prediction research, we support laboratory and theoretical studies and extensive networks of instruments and surveys, chiefly along the San Andreas Fault in California. In fiscal year 1984, Survey scientists published a total of over 400 reports and maps giving the results of their earthquake research.

Since 1978, we have conducted 13 workshops with the support of other agencies to describe the application of this research to State and local officials, the professional and private sector, and the general public.

Our earthquake hazards assessments are serially focusing in 3-year intervals on earthquake-prone areas of the country. A major report on the earthquake hazards of the Los Angeles region has just been completed and will be published this summer.

We are currently working with the State of Utah on earthquake hazards along the Wasatch Fault, a region that contains the populations of Salt Lake City, Provo, and Ogden.

We have formal agreements with many foreign countries with programs for earthquake prediction and earthquake hazards mitigation research. The most active of these exchanges are with Japan and the People's Republic of China. We maintain communication with scientists in the Soviet Union working on similar problems.

We are particularly proud of the scientific accomplishments achieved through the Earthquake Hazards Reduction Program, and I would like to point out a few of those. In the area of crustal deformation, our geologic and geodetic studies have allowed us to determine how and at what rates the Earth's crust is deformed in various parts of the country.

The detailed geologic studies of fault zones have allowed us to determine how often a particular fault zone has broken in the past, far beyond the extent of the historical record. The combination of geodetic and earthquake recurrence studies has provided quantitative estimates of earthquake potential along the San Andreas Fault.

Regional seismograph networks are being used to define the seismicity patterns and active geological structures in most earthquake-prone areas. We have demonstrated that reliable epicenters can be generated by computer processing automatically, accurately, and within a matter of seconds.

We have completed a series of ground-shaking maps that are being incorporated into building codes. Our understanding of the details of how a fault breaks has increased dramatically through theoretical and observational studies. This understanding can be used to estimate strong ground shaking under specific conditions.

We have developed theoretical and laboratory models for earthquake prediction. These models are being used to guide well-focused earthquake prediction experiments using instruments specifically developed and designed for prediction.

In summary, we have a vigorous program on earthquake hazards reduction studies. Working with FEMA, the National Bureau of Standards, and NSF, we are making progress toward the goal of saving lives and reducing losses from earthquakes. We look forward to continuing that work.

Thank you.

I am now prepared to answer any questions you might have for me on this program.

[The statement follows:]

STATEMENT OF DR. DALLAS L. PECK, DIRECTOR, U.S. GEOLOGICAL SURVEY, DEPARTMENT OF THE INTERIOR

Mr. Chairman, I am pleased to appear before this subcommittee to participate in a hearing on the reauthorization of the Earthquake Hazards Reduction Act of 1977. This is the fifth opportunity for the U.S. Geological Survey (USGS) to review its program and progress achieved through research and other activities authorized by the National Earthquake Hazards Reduction Act of 1977. The USGS has been a full and active participant in the National Earthquake Hazards Reduction Program for eight years. The USGS is primarily a scientific bueau engaged in geological and hydrological research, natural resource assessments, data collection, and mapping. Within the national earthquake program our chief responsibilities are for earthquake hazards assessments, earthquake prediction research, and earthquake data and information dissemination. Additionally, however, we have played a key role in working with State and local governments in the utilization of earthquake hazards studies and the development of policies for earthquake hazards reduction. In this testimony we shall outline briefly the organization of our earthquake hazards program, give highlights of our activities during the past two years, and indicate future directions of our work. Further details of our past accomplishments and future plans can be found in the National Earthquake Hazards Reduction Program reports to Congress for fiscal years 1982, 1983, and 1984 and the recently completed Five-Year Plan of the program for fiscal years 1985–1989 also provided to the Congress.

OVERVIEW OF THE USGS EARTHQUAKE PROGRAM

The activities of the USGS under the National Earthquake Hazards Reduction Program are conducted in the Office of Earthquakes, Volcanoes, and Engineering of the Geologic Division. This office is responsible for work on all geologic hazards—earthquakes, volcanoes, and landslides—and in this respect it is probably unique in the Federal Government. The organizational structure allows for certain economies in research, monitoring, and instrument development, in that some techiques can be applied to the study of more than one geologic hazard.

The funding for the USGS earthquake program has remained fairly constant over the past eight years; in FY 1978 $30.2 million was appropriated for earthquake studies; in FY 1985 this figure is $36.6 million and the President's budget for FY 1986 contains a request for $34.6 million, which will be adequate for us to carry forward this important work. Each year about one-quarter of our appropriation is applied to grants and contracts to support complementary investigations by universities, State agencies, and private firms.

In FY 1983, after thorough review, we reorganized our earthquake-related activities into five major elements. This reorganization reflects progress that has been made to date and redirection of our resources into those areas where we believe the greatest return can be realized. The five elements of our current program and a brief description of these elements are given below.

I. Regional tectonics and earthquake potential.—The objective of this element is to understand the geology of an earthquake-prone region and estimate its earthquake potential through studies of fault slip rates, characteristic and maximum earthquakes, and earthquake recurrence intervals. Supported activities include the mapping and characterization of active faults, operation of regional seismograph networks to monitor current seismicity and to identify active and potentially hazardous geologic structures, and the combination of geological and geophysical data to yield quantitative estimates of regional earthquake potential. This information can be used not only in the focusing of our own on-going efforts, but also by other Federal, State, and local agencies in the direction of earthquake mitigation and emergency response planning activities. In FY 1985, approximately $8.5 million will be spent on work under this element.

II. Earthquake prediction research.—The objective of this element is to predict the time, place, and magnitude of damaging earthquakes. Theoretical, laboratory, and observational studies are being carried out as part of our research. Our chief observational effort is to measure various physical and chemical properties of the Earth's crust along active faults and to determine how these properties vary prior to large earthquakes. These field experiments require considerable judgement and patience because we have to assess where earthquakes are likely to occur, install the instruments, and then wait for nature to complete the experiement. The earthquake potential studies carried out under the first program element described above are of great value in choosing those areas where measurements for earthquake prediction purposes should be concentrated. In addition to field experiments, we also support theoretical studies and laboratory experiments that allow us to develop realistic physical models for rock failure and earthquake occurrence. In the current fiscal year, we are spending approximately $14 million on earthquake prediction research.

III. Regional earthquake hazards assessments.—This newly created element has as its objective the delineation, evaluation, and documentation of earthquake hazards and risk in specific areas. It establishes a basis for specific loss-reduction measures at the local level. The goal is to provide the integrated, comprehensive research and generic information needed to reduce earthquake losses in populated areas through understanding of the source, size, frequency of occurrence and physical effects of earthquakes. These effects include ground shaking, fault rupture, and landslides and liquefaction caused by strong earthquake shaking. Our strategy is to build a foundation of knowledge of the earthquake hazards in all seismic regions of the United States and serially focus on each individual region during a three-year period, summarizing and synthesizing what we have learned. This element has a strong component of research application: workshops involving scientists, government officials, and the general public are held in each region to describe the problems and to explain how State and local officials and the private sector may use USGS research products to reduce earthquake hazards. In FY 1985, $5.9 million is being directed toward support of this element.

IV. Earthquake data and information services.—The objectives of this element are to provide timely information to the public and to public safety officials on earthquake occurrence and to collect, archive, and distribute data for seismological research. We operate the National Earthquake Information Center in Golden, Colorado, which provides 24-hour monitoring of domestic and foreign earthquake activity. With support of other Federal agencies and in cooperation with many foreign institutions, we maintain a 130-station worldwide seismograph network. Data from this global network are used in general seismological research, not only by the USGS but also by scientists supported by the National Science Foundation, Department of Defense, and other agencies. Funding for this element this year is $4.4. million.

V. Engineering seismology.—This element is concerned with the measurement, analysis, and theoretical estimation of strong shaking of the ground and structures near earthquake epicenters. The results are used by engineers and architects in the design of earthquake-resistant structures. The data are extremely important in the siting, design, and construction of critical facilities. In FY 1983, responsibility for the National Strong Motion Network was transferred from the National Science Foundation to the USGS. This is a network of specially designed instruments that record the very strong shaking of nearby earthquakes; shaking that exceeds the recording range of conventional seismometers. This "strong motion" network consists of about 1,000 instruments; about half of these we maintain on behalf of other agencies such as the Corps of Engineers and the Veterans Administration. Under this element we support research to develop the theoretical basis for estimating the amplitude, frequency, and other characteristics of strong ground motion, and to develop new analytical techniques to provide the most useful presentation of strong motion data to the engineering community. In FY 1985 support for this element is $3.2 million.

PROGRAM HIGHLIGHTS

We would like now to call your attention to those aspects of our program we feel are of particular significance.

EARTHQUAKE POTENTIAL ESTIMATES

Research supported by the USGS on quantitative, earthquake potential estimates (in a sense, long-term earthquake predictions) and estimates of strong ground shaking due to earthquakes has proceeded rapidly, providing significant new information on the long-term likelihood of major earthquakes in seismically active areas. Geologists at the USGS, the California Institute of Technology, and other institutions have, through detailed studies of fault zones, demonstrated that the dates of large prehistoric earthquakes can be determined from the geologic record. Scientists from Columbia University, the University of California, and the USGS have combined these results with seismological and other data to provide quantitative estimates of recurrence times of earthquakes in California, Nevada, and elsewhere. From estimates of recurrence times and knowledge of the last large earthquake in a region, general or long-term predictions, accurate to within a few years or decades, may be made. Figure 1 summarizes the results of this type of study for the San Andreas fault in California.

The results of this work can be used to direct further research and mitigation efforts. If, for example, limited state or local resources are available for strengthening highway bridges, earthquake potential estimates can be used to define those areas where earthquakes are more likely to occur and where strengthening should begin.

THE PARKFIELD EARTHQUAKE PREDICTION EXPERIMENT

On the earthquake potential map of the San Andreas fault shown in Figure 1, that portion of the fault near Parkfield, California, shows a high probability of experiencing a magnitude 6 earthquake within the next 30 years. Although other regions of the State may experience magnitude 6 events before the next occurs near Parkfield, this 16-mile long section of the fault has a well determined earthquake history from which the magnitude and approximate time of the next earthquake can be estimated. Earthquakes have occurred near Parkfield in 1857, 1881, 1901, 1922, 1934, and 1966, with an average recurrence time of about 22 years. If the next Parkfield earthquake follows this pattern, it should occur within the next few years.

The last three Parkfield earthquakes share remarkably similar, characteristic features. These features—magnitude, length and location of rupture along the fault (rupture zone), and starting location of the fault break (epicenter)—define the characteristic Parkfield earthquake. The concept of a characteristic earthquake with recurring features means that an experiment to predict that event a few hours or days before it happens can be tailored to these characteristic features. Since the likely time of occurrence of the next Parkfield earthquake is near, and because previous events that have been so similar, Parkfield provides a unique opportunity to conduct an experiment to observe variations in the crust of the Earth that may precede the earthquake.

We are currently putting substantial effort into monitoring the state of the Earth's crust in the Parkfield region. Seismometers, strainmeters, creepmeters, (instruments that measure movement on the fault), geodimeters (very sensitive geodetic measurement devices using laser light), and other instrumentation have been installed and are being monitored. Data from this equipment are collected at a central location and quickly analyzed on a continuous basis.

The results of both the scientific studies and information transfer processes related to the Parkfield experiment will be very important to future work on earthquake prediction.

EARTHQUAKE PREDICTION STRATEGY

The Parkfield study and recent consideration and discussion of various options based on specific earthquake prediction experiments have helped define our observational strategy for earthquake prediction.

At Parkfield, we have a well-developed concept of the earthquake we are trying to predict—its magnitude, location, and the time interval in which it is expected. The design of the Parkfield observational experiment has been made with reliability and redundancy in the instrumentation in mind to ensure that accurate and continuous data are obtained. Instruments of different design to measure the same physical phenomena are installed near each other; instruments of the same design are deployed in tandem. These efforts are being made to minimize the chances of being fooled by a spurious signal related to one instrument or one design, and to increase our chances of recognizing real precursory phenomena as they appear on several instruments.

We see earthquake prediction efforts elsewhere being influenced by this concept—the deployment of a cluster or clusters of instruments concentrated along specific sections of the fault for the purposes of predicting earthquakes thought to be characteristic of that section. During the autumn of 1984 we developed a strategy paper on options for earthquake prediction based on this reasoning. The paper has been reviewed by several groups, including a committee of the National Research Council (NRC) and the California Seismic Safety Commission (CSSC). The paper considered strategy options ranging from continuing the present research program including the Parkfield experiment, to adding a few additional clusters in southern California in regions where specific events are expected, to deployment of 40–60 clusters throughout California. All groups endorsed the cluster approach and our activities at Parkfield and some indicated we should proceed with a few more clusters in other regions of southern California. There was no support for options involving comprehensive deployment of 40–60 clusters throughout the State.

RESEARCH APPLICATION

We have, since 1978, conducted a series of 13 workshops to address specific earthquake problems of regional or local interest, to present the state-of-knowledge regarding these problems to State and local officials, and to lay the course for future work. These workshops, conducted by the USGS and supported by the USGA and other Federal, State, local, and private organizations, have been extremely effective mechanisms for the diffusion of knowledge about earthquake hazards throughout the Nation and about what can be done to reduce them. The workshops have brought together more than 1,000 producers and users of earthquake hazards information in almost every earthquake-prone part of the United States. In general, we have been concentrating on areas outside of California, areas in which the earthquake problem may be less well understood, and local officials and the public less well informed on the issues. The proceedings of each of these workshops have been published in a USGS report.

The first workshop on "Communicating Earthquake Hazards Reduction Information" was held in Denver in 1978. Others have been held in Los Angeles, California; Santa Fe, New Mexico; Knoxville, Tennessee; St. Louis, Missouri; Charleston, South Carolina; and Albany, New York. Additional workshops are planned for Anchorage, Alaska; Los Angeles, California; and Cheyenne, Wyoming. These workshops have contributed to the formation of State and regional seismic safety organizations and commissions. Such organizations currently are active in California, Tennessee, Kentucky, South Carolina, New York, and the Central Mississippi Valley. Legislation is pending for a seismic safety commission in Washington State, and planning is underway for a New England seismic safety organization. Recently, the California Seismic Safety Commission authorized the drafting of a "California (Earthquake) Hazards Reduction Act" bill to describe a "state multiyear seismic safety program.".

Clearly, the research and activities supported by the National Earthquake Hazards Reduction Program are reaching the State and local level and steps are being taken to implement the results of the program.

EARTHQUAKE STUDIES IN THE EASTERN UNITED STATES

Evaluating seismic hazards and earthquake potential in the United States east of the Rocky Mountains is complicated by the relative infrequency of large earthquakes and by the general absence of mappable, active faults. As a result, the association of seismicity with geologic structures showing surface expression, like those found in the Western United States is difficult. The earthquake hazards and risks from earthquakes in the Eastern United States are none-the-less real: damaging and destructive earthquakes are known to occur, the crust of the Earth transmits seismic shaking to much greater distances with less attenuation in the East compared to the West, population densities are high, and many of the population centers have significant numbers of older buildings not designed or constructed to modern building codes.

The cause—or causes—of widespread but infrequent seismicity in the Eastern United States generally is not well understood. Much has been learned in the last decade, however, and there is an accumulating body of evidence that indicates that eastern seismicity is associated with ancient (geologically speaking) fault zones that are rejuvenated by modern stress patterns in the Earth's crust. It is now thought, for example, that some earthquakes along the eastern seaboard are associated with faults that may have initially formed about 200 million years ago during the opening of the Atlantic basin. The difficulty lies in determining the cause and orientation of modern stress regimes and the geometries and conditions that cause ancient faults to be reactivated by modern stress patterns.

Since these ancient structures are almost always buried beneath younger geologic strata, defining their nature and geometry relies heavily on expensive, deep-sounding techniques originally developed for oil exploration. Perhaps the most complete investigation conducted so far in the Eastern United States has been in the New Madrid seismic zone of the central Mississippi Valley, the site of major earthquakes in 1811 and 1812. Here geologic, aeromagnetic, gravity, and seismic reflection refraction techniques have defined a northeast-southwest trending zone of faulting in the crust beneath the Mississippi River valley in adjoining parts of Arkansas, Missouri, Kentucky, and Tennessee. This zone or rift is thought to have been formed more than 600 million years ago; however, contemporary seismicity in the region shows close association with these buried ancient faults. Present-day seismicity and crustal movements represent the response of these structures to the current east-west compressive stress field.

These studies have a significant practical application. Once the conditions for the reactivation of ancient structures are defined, and their locations determined, earthquake recurrence intervals and areas of high, and low, seismic risk in the Eastern United States can be specified with higher confidence and accuracy.

Studies similar to those in the Central United States have been carried out in the Charleston, South Carolina, region near the epicenter of a large earthquake that occurred in 1886. These studies have proceeded with cooperation and support from the Nuclear Regulatory Commission; however, the joint effort has been unsuccessful in identifying a buried structure as the cause of this earthquake. Recently, important information has come to light regarding past earthquakes in the Charleston region. Detailed geologic studies of the upper tens of feet of soil in the region show features that indicate that three or four earthquakes, including and of similar magnitude to the 1886 event, have occurred over the past twenty to thirty thousand years.

These results indicate that the 1886 Charleston earthquake was not a unique event and the yet undiscovered structure or geologic feature that gave rise to it is capable of future seismic activity.

FUTURE PROGRAM DIRECTIONS

During the next few years, our earthquake studies will concentrate more on those techniques and approaches that have enjoyed greatest success in the past.

Detailed geologic studies of fault zones have proven extremely valuable in the assessment of earthquake potential and hazards. This work involves detailed fault mapping and excavation of fault zones, primarily in the western United States, to determine the level of prehistoric earthquake activity. This work will be sustained and expanded when possible. The seismometers in many of our dense, regional, seismograph networks were designed and built over 20 years ago, and many of our current recording practices were developed before digital technology was widespread. The costs of maintaining conventional networks and of data transmission via telephone lines have risen sharply in the past few years. These increases and the technical limitations of current systems are forcing us, in some regions, to consider other monitoring strategies. Such strategies may employ fewer instruments of modern design along with digital data processing, transmission, and analysis. These modern systems have the promise of providing new information on regional seismicity, essential to the assessment of earthquake potential.

In earthquake prediction research, as described above, we shall continue to concentrate instruments at specific sections of a fault where a characteristic earthquake has been defined and the potential is high for its recurrence. Experiments similar to the one being developed at Parkfield represent the most rational observational approach to earthquake prediction. Theoretical and laboratory studies will be continued to form a basis for development of an understanding of the observational experiments.

Regional earthquake hazards assessments are now in the second year of a three-year concentrated effort in Utah. With the cooperation of the State, through its Geological and Mineral Survey, we are making a detailed study of the earthquake hazards along the Wasatch Front, the area containing the towns of Provo, Salt Lake City, and Ogden. Our next target area for a detailed hazard assessment will be south central Alaska, the region containing Anchorage and environs. Preliminary discussions are underway with Alaska State officials to formulate and formalize this program.

We shall continue to work closely with the Federal Emergency Management Agency in activities that foster the implementation of loss-reduction measures in the various seismically active regions of the Nation.

In the area of earthquake data and information collection and dissemination we shall maintain our current services while we work with the National Science Foundation and the Defense Advanced Research Projects Agency to improve the quality of data available from worldwide sites.

Finally, we shall work closely with the engineering community to ensure that the data and analyses we are providing on strong earthquake shaking are meeting their needs and requirements. We shall continue our theoretical studies based on this information to increase our understanding of the physics of the earthquake source and thus predict strong earthquake shaking under conditions where no observations are available.

CONCLUSION

This concludes the testimony on the authorization of the USGS to continue work in the National Earthquake Hazards Reduction Program during Fiscal Years 1986 and 1987. In this testimony we have reviewed briefly our current program, highlights of our progress, and future directions we intend to pursue. The accomplishments of the program are significant and the level of understanding and awareness of earthquake hazards in the United States is much greater that it was when the program began in 1978. Although much work remains to be done, the efforts that have been made so far provide a solid base for extending our progress efficiently and effectively.

[The following information was subsequently received for the record:]

QUESTIONS OF THE CHAIRMAN AND THE ANSWERS

Question. In my State of Missouri, we are naturally concerned about the potential for catastrophic earthquakes. Can each of you comment on how your agency has reduced the hazard of a potential earthquake along the New Madrid fault? What research have you done in this area? And what more should be done under the Earthquake Hazards Reduction Act?

Answer. The Geological Survey has conducted a variety of geologic, geophysical, and geochemical studies of the New Madrid area since the 1970's. USGS investigations, involving a number of cooperating Federal, State, and university scientific groups, revealed that modern seismicity in the New Madrid region is associated with a reactivated ancient fault zone (the New Madrid fault zone) that lies along the axis of a buried northeast-trending rift in the upper Mississippi embayment. Geological Survey studies of earthquake magnitude-frequency relationships and trench investigation of ancient liquefaction features (sand boils) suggest that large earthquakes recur in the New Madrid region about every 600 to 700 years.

The Geological Survey (in cooperation with the Federal Emergency Management Agency) also has convened three workshops on the earthquake hazards of the New Madrid area (St. Louis, Missouri, May 1982; Little Rock, Arkansas, September 1983; and Cape Girardeau, Missouri, November 1984) to communicate earthquake hazards reduction information to concered Federal, State, and local officials, and to the general public.

The Geological Survey is continuing studies of the New Madrid fault zone to a) more accurately establish the recurrence interval of damaging earthquakes in the New Madrid area; b) assess the economic impact of a damaging earthquake in the New Madrid area; and c) more fully explore the buried rift beneath the Mississippi River Valley.

QUESTIONS OF SENATOR PRESSLER AND THE ANSWERS

Question. I have been very interested in developing the Continental Scientific Drilling Program (CSDP), in which your agency is involved. I am particularly interested in hearing your thoughts on the extent, if any, to which the specific programs of the Earthquake Hazards Reduction Act efforts could be integrated with the CSDP.

Answer. The CSDP was conceived to address a wide range of geological problems that can only be resolved by the direct sampling of the materials and properties of the Earth's crust through drilling. Although the justification for the CSDP is scientific, the results of the program will have application to more mission-oriented programs such as hazardous waste disposal, resource assessments, and earthquake hazards reduction. We recommend, however, that the CSDP not be formally integrated with any mission-oriented program in that it may then lose its wide scientific support and application.

Question. In comparison to other techniques, how effective would continental crust drilling be in achieving the goals of the Earthquake Hazards Reduction Act?

Answer. CSDP can contribute to the goals of the earthquake program by providing data on the materials and properties at depths where earthquakes occur in seismic regions. This information will be used in theoretical and laboratory models of earthquake occurrence; models that guide earthquake prediction experiments and the interpretation of prediction data. CDSP holes in seismic regions may also be used, once general scientific studies are complete, to house instruments useful in earthquake prediction.

Question. Specifically, what is the probability that an effective CSDP could substantially increaso the lead time for earthquake warnings?

Answer. CSDP activities in seismic regions will increase the rate of our understanding of why and how earthquakes occur in those regions and increase the number of opportunities to put sensitive earthquake prediction instruments in deep holes, away from atmospheric, cultural, and other superficial noise sources. It is impossible to say whether the CSDP will increase the warning time of any specific earthquake, but it is clear that we cannot make rapid progress in earthquake prediction without deep holes in earthquake zones.

QUESTIONS OF SENATOR HOLLINGS AND THE ANSWERS

USGS EARTHQUAKE PROGRAM

Question. It seems clear now that making accurate, short-term predictions of major earthquakes is more difficult than Congress anticipated when it passed the Earthquake Hazards Reduction Act.

Why is this the case? Why is earthquake prediction more complex and difficult than we once thought? And when can we expect to have an accurate way to foresee these tremors?

Answer. Many of the early theories and hypotheses on how earthquakes could be predicted were based on foreign reports and incomplete data. In U.S. earthquake prediction research these theories have been systematically evaluated and many of them, such as unusual animal behavior before earthquakes, have been rejected.

The most promising earthquake prediction theory, in simple terms, states that before the crust of the Earth breaks in a large earthquake, it will experience minor cracking and deformation. Most mechanical systems show such symptoms before they fail catastrophically. Foreshocks and ground deformation have been observed in epicentral regions prior to large earthquakes.

The problem of establishing criteria for reliable earthquake prediction involves installing sensitive equipment in areas where earthquakes are expected and then waiting until the earthquake occurs. The period of observation may require years or decades. During these periods the equipment must be maintained and data analyzed on a routine basis. Only after several such experiments, which can run concurrently in different regions, will we gain the experience necessary for reliable earthquake prediction.

We conduct laboratory and theoretical research on earthquake occurrence and earthquake precursors to complement these field studies. We also have formal scientific exchanges with Japan, the People's Republic of China, and the Soviet Union so that we may gain from foreign experience in earthquake prediction.

Question. While your FY 1985 appropriation for earthquake work is $36.6 million, the President's request for FY 1986 is $34.6 million.

How will this reduction affect USGS's work in this area? What activities will be cut or stretched out? Will the amount of money spent on grants and contracts to universities, State agencies, and private firms be cut?

Answer. Part of the proposed reduction is possible because procurement of additional instrumentation funded in the FY 1985 appropriation will be completed. However, some project reductions, including the discontinuation of five research projects or studies of earthquake mechanisms and earthquake methodologies, will be necessary. These reductions will "stretch out" theoretical and laboratory research and decrease the density of instruments in some seismically active areas.

Approximately one-fourth of our annual appropriation is directed toward grants and contracts to universities, State agencies, and private firms. This proportion will be maintained under reduced funding.

Question. In your testimony, you say that the results of the Parkfield experiment will be very important to future work on earthquake prediction.

Will you briefly tell the Committee what results you expect from Parkfield and how these results will help improve our knowledge of earthquakes and our ability to predict them?

Answer. We expect a moderate earthquake (about magnitude 6) to occur in the Parkfield area about every 22 years. The last magnitude 6 event occurred in 1966. By concentrating geophysical instrumentation in the area, we expect to detect and measure ground deformation and changes in microseismicity prior to the next Parkfield earthquake. This experiment will allow us to design earthquake prediction strategies and instrumentation for application at other sites.

Question. I have been very impressed by the work that USGS and South Carolina scientists have recently done near my home of Charleston, South Carolina. As I understand it, examinations of "sand blows"—areas of soil that liquefied during the disastrous 1886 earthquake—indicate that several earthquakes have occurred in the Charleston area.

Is it correct to infer that other earthquakes may occur in the Charleston area in the future? How often can we expect such earthquakes, and with what damage? And since many other eastern States have geology similar to South Carolina's, can we expect Charleston-type earthquakes elsewhere along the east coast?

Answer. The discovery of "sand blows" from prehistoric earthquakes in the Charleston earthquake is conclusive evidence that the 1886 event was not unique. This means that future large earthquakes, as large as the 1886 event, can be expected in the Charleston region; however, the data available at this time will not support an unequivocal estimate of repeat times of these large events. The inadequate data available suggest that the time intervals between large earthquakes in the region to be at least several hundred years; however, this is a very rough estimate. Smaller, yet damaging earthquakes could occur with greater frequency.

In a contemporary scenario (U.S. Geological Survey Open-file Report 83–843) for a repeat of the 1886 earthquake Dr. Charles C. Thiel, Jr. estimated that 4,000 lives might be lost, 17,000 persons injured, 125,000 housing units lost, and up to $25 billion in damage.

The geologic setting near Charleston is found elsewhere along the east coast, suggesting that Charleston-type earthquakes may occur at other locations.

Question. In your testimony, you mention that the cause of eastern earthquakes is not well understood and that the ancient faults thought responsible are buried deep in the earth.

Given this situation, what additional research is needed to better understand the location and operation of these ancient structures? Is any such research planned? Will the new Continental Lithosphere program funded by NSF provide any information useful in understanding eastern earthquake activity?

Answer. Careful search for earthquake-related features, like sand blows, is needed in those areas where the general geologic setting is similar to that found at Charleston. This will help establish whether large prehistoric events have occurred in these regions.

Additionally, subsurface seismic exploration techniques similar to those used in oil and gas exploration are needed to define buried faults in those regions thought to be capable of giving rise to large events. These regions also may be identified using geologic studies and by their higher seismic activity (at low magnitude levels) compared with neighboring regions. Because the seismic exploration technique is particularly expensive, there are no plans within the U.S. Geological Survey (USGS) earthquake program to pursue research with that technique.

The NSF Continental Lithosphere program and the USGS Deep Continental Studies program use seismic exploration techniques and may provide data useful to understanding east coast seismicity. However, these programs have broad objectives and earthquake concerns compete with others in the direction of these programs.

Question. Much of USGS's earthquake-related research in the Carolinas has been supported by the U.S. Nuclear Regulatory Commission. Your testimony says that so far the joint effort has been unsuccessful in identifying a buried structure as the cause of the 1886 Charleston earthquake. Yet I understand that the NRC may end its support for this joint research, despite the need to understand what seismic problems might affect nuclear power plants in the area.

What is the NRC's position on this issue? If they do cut off funding, will USGS—with its limited budget—be able to continue these investigations?

Answer. We do not have a clear understanding of the Nuclear Regulatory Commission's position on this issue and would rather this question be put directly to the Commission.

Although we shall continue work in the Eastern United States and the Charleston region, we would not be able to sustain or pick up most of the work in these regions that NRC currently supports.

CHILEAN EARTHQUAKE

Question. Do you have any updated estimates of the number of people killed, the number of structures destroyed or damaged, and the dollar amount of property damage from the recent Chilean earthquake?

Answer. The Government of Chile reports that at least 176 persons were killed in the March 3, 1985, Chilean earthquake and 2,483 injured. More than 45,000 homes were reportedly destroyed; another 76,000 were heavily damaged. About 372,000 persons were left homeless. Some estimates suggest that property losses exceeded $500 million.

Question. I understand that USGS sometimes sends its experts to the scene of foreign earthquakes, in order to study the fault, gather data on the tremor, and survey the structures affected.

Was that done in the case of the Chilean earthquake? If so, what data do you expect to gather? How will that data improve our understanding of American fault lines? Will the data be used to help the Chileans better understand earthquake hazards in their own country and to help them develop better mitigation measures?

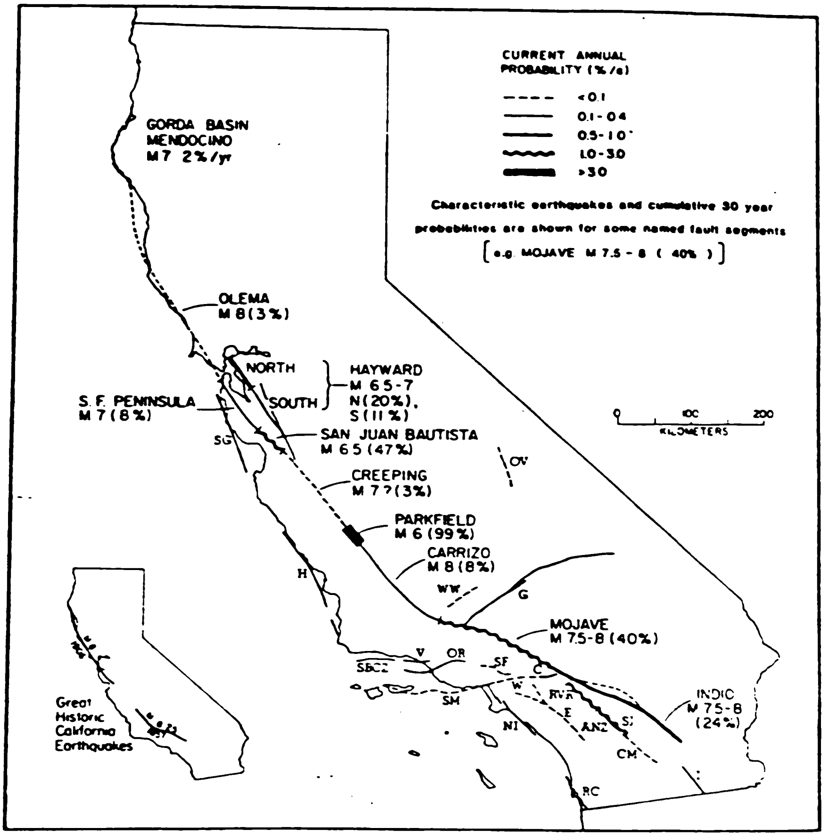
Answer. Yes. A team of four USGS scientists and technicians went to Chile after the earthquake to conduct a joint U.S.-Chile postearthquake investigation.

The USGS team deployed portable seismographs and several strong-motion instruments in the epicentral area of the March 3, 1985, earthquake to record aftershocks and their grounds motions. The team also conducted a careful evaluation of the geologic effects (liquefaction, landslides, etc.) of the earthquake, and determined the distribution of earthquake damage, noting types of structures affected and intensities of ground shaking. The USGS study should provide important, quantitative data on the strong amplification effects of earthquake ground shaking.

The Chilean earthquake investigation has provided important insights into the mechanism of earthquake failure in plate subduction zones like those along the south coast of Alaska and along the coast of the Pacific Northwest. The Chilean earthquake also provided the first comprehensive records of the strong grounds motions generated by very large earthquakes. These records will be used by engineers and architects to improve earthquake-resistant building design and construction.

Studies of the geologic effects of the March 3, 1985, earthquake revealed that extensive areas of the Chilean port cities of San Antonio and Valparaiso are underlain by beach sands and fill that are susceptible to liquefaction. The hazards of these areas, which will likely fail again in future large earthquakes, must be considered in the reconstruction of the port cities.

The earthquake strong motion data will be used by Chilean engineers and architects to improve earthquake-resistant building design and construction in the epicentral area, as well as throughout Chile.


CURRENT ANNUAL PROBABILITY (%/a)
<0.1
0.1-0.4
0.5-1.0
1.0-3.0
>3.0
Characteristic earthquakes and cumulative 30 year probabilities are shown for some named fault segments
[e.g. MOJAVE M 7.5-8 (40%)]
GORDA BASIN MENDOCINO M7 2%/yr
OLEMA M 8 (3%)
NORTH
SOUTH
HAYWARD M 6.5-7 N (20%), S (11%)
S. F. PENINSULA M 7 (8%)
SG
SAN JUAN BAUTISTA M 6.5 (47%)
CREEPING M 7? (3%)
OV
0 100 200 KILOMETERS
PARKFIELD M 6 (99%)
CARRIZO M 8 (8%)
H
WW
G
MOJAVE M 7.5-8 (40%)
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OR
SBCI
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SM
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E
ANZ
SJ
NI
CM
RC
INDIO M 7.5-8 (24%)
Great Historic California Earthquakes

FIGURE 1

Senator GORTON. Thank you very much, Dr. Peck.

Senator Hollings has some written questions for both you and Dr. Suh.

Dr. Suh, under the same circumstances, your entire statement will be included in the record.

Dr. SUH. I am pleased to report to you on the status of earthquake hazard mitigation research at the National Science Foundation. As per your suggestion, we are pleased to submit written testimony for the record.

Earthquake research at NSF has received significant attention since the Earthquake Hazards Reduction Act in 1977. Since then, NSF has obligated $195 million in seismic research. Approximately 68 percent of the funds have been obligated by the Engineering Directorate, and 32 percent in the Astronomical, Atmospheric, Earth, and Ocean Sciences Directorate.

The NSF's activities related to the earthquake hazard mitigation program include two kinds of research. The first deals with the basic scientific research on the motion and structure of the Earth's crust and its relationship to the genesis of earthquakes.

The second kind of research deals with engineering research for the mitigation of earthquake hazards through a better understanding of siting and geotechnical issues, structural response, response of architectural mechanical elements, and systems issues ranging from effective application of research results, information dissemination, technology transfer, and assessment of various mitigation measures, which includes lifeline support systems.

I would like to spend a few minutes going over the overall results of NSF-supported and sponsored research. The results of the NSF-sponsored research programs are impressive by any measure. First of all, thanks to the support, the United States now has the strongest academic community in seismic research in the world, both in geophysics and in engineering.

Also, thanks to research, we have incorporated much of the results in building codes, and many of these building codes have improved a great deal. We also generated many design aids in the form of computer software and other useful information which have been disseminated to the community. We also have a much better understanding of how earthquakes are generated and how they propagate.

Because of the research results, many of the new design concepts such as eccentric bracing and new base isolation techniques have been introduced. And finally, new legislation in State and local governments has been introduced to reduce the liability of local officials so they can more effectively incorporate many of these technological breakthroughs into their city regulations.

And I think I can go on and list many other accomplishments of the research community. However, I think it is sufficient to say that the continuing support of the research community has resulted in mitigation measures envisioned by the Congress in 1977.

Notwithstanding these advances, obviously we have still much to do. The question, then, is where do we go from here? I would like to talk about several items as to what we ought to do in the future years.

First of all, we should continue to support the research community and maintain the focus we have established in the past. Through the research, I think we can fully advance the fundamental understanding in the field of geophysics and also in earthquake engineering. Based on this understanding, we need to develop new design methodologies for earthquake-resistant structures, better lifeline support systems, et cetera. Then we need to promote better technology transfer between the research community, and we ought to spend more time concerning ourselves with information dissemination.

We also are initiating new initiatives in our Earth sciences division for the continental lithosphere program, which should enhance our understanding of the basic Earth structure issues.

Another item we would like to consider starting in fiscal year 1985 and continuing into fiscal year 1986 is the possibility of undertaking major systems studies, so we have a better understanding of how lives will be lost during earthquakes, and how we will lose our property, so that we can better focus our research in some of these important areas.

Another plan we have is to consider the establishment of a major center for earthquake mitigation hazard research at one of the universities, cofunded with one or more of the States. The idea is to promote technology transfer by having States involved in this kind of research effort, and also to enable centers to undertake major, coherent research projects rather than having a large number of fragmented research projects undertaken by individual researchers.

And finally, we would like to see if we can consider the possibility of establishing large-scale test facilities that the universities so badly need to conduct their research.

These are items we would like to consider during the coming years, and we are going to spend a substantial sum of the engineering research funds for this purpose. As of now, the Engineering Directorate is spending roughly about 17 percent of the single investigator research program funds to support the earthquake hazard mitigation research. This is by far the largest program we have in engineering on a specific topic, and we are interested in making sure that indeed the funds will be used in the most effective way and that we can generate the intended results.

Finally, I would like to just make a few concluding remarks about what has happened and where we go from this point. I think the earthquake engineers in the United States are the best in the world, and we need to make certain that our universities continue to generate these kind of people in the years ahead. In order to make sure that we can indeed deal with mitigation issues, we need to develop both broad, fundamental research and more focused, innovative research on problems that may more significantly affect mitigation of earthquake hazards.

I believe that the research community has responded to the challenges posed by the Congress in the past. With adequate encouragement and support, I am sure that they will continue to do their best to meet the needs of the Nation in this important area.

Thank you, Mr. Chairman.

[The statement follows:]

STATEMENT OF DR. NAM P. SUH, ASSISTANT DIRECTOR FOR ENGINEERNG, NATIONAL SCIENCE FOUNDATION

Mr. Chairman and Members of the Subcommittees, I am pleased to report to you today on the status of Earthquake Hazard Mitigation Research at NSF. Since the passage of the Earthquake Hazards Reduction Act in 1977, NSF has obligated about $195 million on Seismic Research in the Directorates for Engineering (ENG) and for Astronomical, Atmospheric, Earth and Ocean Sciences (AAEO). Approximately 68% of the funds have been obligated by the Engineering Directorate and 32% in the Astronomical, Atmospheric, Earth and Ocean Sciences Directorate.

Under the Earthquade Hazards Reduction Act the responsibility for different activities related to Earthquake Hazard Reduction is primarily assigned to four specific agencies, although other agencies participate in the program in connection with their operational responsibilities. FEMA is designated as the lead agency.

Earthquakes are not unique to a particular country, and to a particular state. The United States has been fortunate in that during its history the severest earthquake, which occurred in New Madrid, Missouri in 1811–12, struck at a time when the population density was low and there were few major constructed facilities to sustain damage. In other major earthquakes we have often been fortunate in that the earthquake struck at a time when population exposure to high-risk situations was at a minimum. Thus the average number of persons who have lost their lives due to earth shaking during U.S. history is relatively low in comparison with other seismically active countries. Loss of life due to a single earthquake event in some countries has exceeded 500,000. The comparatively low number in the U.S., however, should not lead us to be complacent, as population densities in seismic prone areas are increasing. This can lead to an increased level of risk, particularly in connection with existing buidings, and other facilities constructed before a knowledge base abut earthquake engineering was available. Although our knowledge of how to design new structures to resist the effects of earthquakes has vastly improved as a result of both the NSF research programs and those of other agencies in the Earthquake Hazard Reduction Act, there are still many gaps and incomplete data on which to base designs. A major thrust in past years' research was to develop methods and information which assure that constructed facilities would not suffer gross failures of a life-threatening nature. For most types of structures the knowledge base which has been developed through NSF research makes it possible to design against such gross failures in new structures. A serious problem still exists, however, in predicting and designing against serious economic losses in many new structures and against loss of service of vital life-line facilities such as water and electrical supply systems. Existing structures also pose a problem due to the difficulties in assessing levels of hazard and balancing potential economic and human losses against costs of retrofitting and upgrading such structures.

The NSF's activities related to earthquake hazard mitigation include research in the earth sciences, engineering, architecture, and the social sciences. These activities are supported through the Earth Sciences Division (EAR) in the Astronomical, Atmospheric, Earth and Ocean Sciences (AAEO) Directorate and the Earthquake Hazard Mitigation Program (EHMP) of the Emerging and Critical Engineering Systems Division (ECES) in the Engineering (ENG) Directorate.

I would first like to describe some of the activities carried on through the Earth Sciences Division (EAR) in the Astronomical, Atmospheric, Earth and Ocean Sciences (AAEO) Directorate.

Seismology and earthquake-related fundamental studies have been of long-term interest to the Earth Sciences Division and have constituted a signficant part of the Division's program for some 20 years. The importance of the National Earthquake Hazards Reduction Program to the Division is in stressing the importance of the research to the concerned scientific community, and in ensuring good coordination both within that community and with the other Government agencies involved.

An understanding of the fundamentals of the earthquake phenomenon and associated processes is essential for the eventual prediction of earthquakes and destructive grown motion. An independent program of fundamental studies, therefore, provides the framework on which a more empirical program of earthquake prediction can be based.

The Earth Sciences Divisions has supported a number of projects to provide the fundamental understanding mentioned above. A few highlights of the kind of research involved are:

Rock Physics and Geologic Structure of the San Andreas Fault Zone from Seismic Reflection and Vertical Seismic Profiling.—The hydraulic and elastic properties of a fault zone, together with the configuration of the zone as a function of depth, hold the key to number of question concerning the earthquake generation process along active faults.

Earth scientists from the academic community in southern California, whose interests include crustal structure and evolution, have formed a regional consortium (CALCRUST) to apply the seismic reflection technique, in combination with geological and geochemical observations, toward and improved understanding of the subsurface in the southwestern U.S. Members of the consortium are: University of Southern California, California Institute of Technology, University of California, Santa Barbara, University of California, Berkeley, San Diego State University, and California State University, Los Angeles. A two-year program by CALCRUST, initiated in 1984, will include a study of the geologic structure of the San Andreas Fault from convention seismic reflection profiling and from vertical seismic profiling (VSP) in deep boreholes.

In this project CALCRUST will emphasize the acquisition of seismic data near the San Andreas fault zone using a vertical sensor string emplaced in a deep borehole (up to 1600 meters) in combination with data recorded at the surface using more conventional methods. Borehole or VSP (vertical seismic profiling) experiments provide a level of detail not commonly obtained via surface arrays alone.

The Earthquake Process.—In order to predict earthquakes and estimate the damage that may be caused by a large earthquake, one needs to understand the physical processes occurring at the source of an earthquake. From this one can understand the physical conditions under which earthquakes occur and one may calculate the expected ground shaking at any place close to or far from the earthquake source. Under NSF funding, scientists at Lamont-Doherty Geological Observatory of Columbia University have been approaching this problem in a novel way—i.e., using a fracture mechanics approach to study the rapid faulting process during the earthquake. The science of fracture mechanics is very advanced and is used extensively by civil, mechancial, aeronautical and other engineers to study how bridges, machines, airplanes, etc. may break under stress. Lamont scientists are using the developments made in this field and are applying them to the study of how the earth's crust breaks during a large earthquake.

The problem is studied by making theoretical models, using large computers, of the speed with which fractures propagate through the earth's crust. One of the important results from these investigations is a new model which may explain why large earthquakes almost always nucleate at depth near the base of the brittle, seismogenic portion of the rigid plates covering the earth's surface and propagate upward and along the plate margins. Essentially, the model predicts that if an earthquake nucleates at shallow depths in the low strength part of a fault, it cannot propagate dynamically into the higher-strength deeper regions; only an earthquake that nucleates in the higher strength part of the fault at dept has the potential to become a large or great earthquake (provided, of course, that other parts of the fault plane are close to failure). These results may have future practical applications.

Earthquakes have, in a large number of cases, been triggered by the filling of reservoirs. Because the impounded water poses a potential hazard, the maximum likely size of such triggered events becomes a question of critical importance. In a few well-studied sequences, (e.g., Lake Jocassee in South Carolina) the earthquakes lie within focal depths of less than a few kilometers. If so, and if the above model is correct, there would appear to be a lower potential for severe earthquake damage than has been anticipated.

Recent surveys of the earth sciences by the National Academy of Sciences (NAS) including a Committee on Science, Engineering and Public Policy (COSEPUP) Research Briefing on the Solid Earth Sciences have recommended that NSF supplement its small grant research programs in earth sciences with selected larger multi-institutional projects aimed at a new and more comprehensive understanding of the continental lithosphere—the outer, relatively rigid layer of the earth, approximately 100 kilometers thick, and underlain by less rigid rocks.

A basic and more advanced understanding of the earth's lithosphere in general, and the structure and characteristics of the crust underlying North America specifically, could result in important scientific discoveries. These, in turn, could lead to breakthroughs in new energy sources and mineral deposits, responsible methods of waste disposal and advances in prediction of earthquakes and volcanic activity.

The Earth Sciences Division has added a new program, the Continental Lithosphere Program (CLP), to address projects of the type envisioned in the NAS reports. Some areas of research within this program may have applicability to the HEHRP. One such area involves seismic investigations of the continental crust. This area includes both seismic reflection profiling and seismic refraction studies and provides the most detailed information on deep structure. The regional consortium CALCRUST mentioned earlier is an example of a project in this area supported by the CLP. CORCORP, the Corsortium for Continental Reflection Profiling project at Cornell University featured in previous years earthquake testimony is another example.

Another priority research area possibly applicable to the NEHRP and identified by the NAS reports is the use of modern, digital, wide-band, wide-dynamic-range, seismograph arrays. Such arrays, linked to computers, can provide high-resolution imaging of the crust and deeper parts of the lithosphere. They may be able to provide the data needed to determine the precise location and mechanism of earthquakes anywhere on the globe in near real time using satellite telemetry. Modern digital data permit the use of sophisticated tomographic techniques (similar to CAT scans in medical science) to map the structure (and possible kinematics) of the lithosphere and deeper parts of the earth. NSF would be cooperating in this area of research with the U.S. Geological Survey which operates the current, largely analog, World Wide Standard Seismograph Network (WWSSN). This network has provided much valuable data for basic seismological research over the past twenty years.

Funding for the program in the AAEO Directorate followed Option B of the guidelines set by the 1976 Newmark-Stever Report throughout the duration of those guidelines. In FY 1985 the Program will be funded at $8.4M. The funding requested for FY 1986 is $11.0M, the increase reflecting funds requested for the priority research areas mentioned above in the Continental Lithosphere Program.

Close coordination among the programs of the Earth Sciences Division, earthquake engineering research, the earthquake prediction program of the USGS, and the earthquake research programs of other agencies is very important. This is attained by close personal contacts of program personnel and by liaison membership on each other's Advisory and Evaluation Committees.

I would next like to describe some of the activities carried out through the Earthquake Hazard Mitigation Program, in the Engineering Directorate. Earthquake Engineering research activities have existed at NSF as a separately identified activity since approximately 1964. As reorganizations within NSF have occurred over the years, the Earthquake Hazard Mitigation Program progressed from its initiation as a part of an integrated Natural Hazards Research Activity to a separate program in the Directorate for Research Applied to National Needs (RANN), the Directorate for Applied Science and Research Applications, the Directorate for Engineering and Applied Science, and the Directorate for Engineering. In a recent reorganization of the Engineering Directorate, the Earthquake Hazard Mitigation Program was placed in the Critical Engineering Systems Section of the Division of Fundamental Research for Emerging and Critical Engineeing Systems. Within this new organizational structure the Earthquake Hazard Mitigation Program is a vital part along with the companion programs, Natural and Man-Made Hazards, and Systems Engineering for Large Structures. They share a common concern for the development of an improved knowledge base for solving such problems as: potential destruction or loss of service; deterioration from age; long-term use or exposure; assessment for safety or serviceability; reduction of future maintenance costs; and innovation in the possible future changed usage of constructed facilities in the United States.

In terms of economic importance, the yearly capital construction costs in the U.S. exceed $360 billion and are the largest single item represented in the economic indicators published by the Department of Commerce. The total accumulated constructed capital investment in the U.S. is thus very substantial and is a vital element in the functioning of economic activity and health of the country.

The Earthquake Hazard Mitigation Program has previously been reported under three Program Subelements: Siting, Design, and Societal Response. These same subelements were used in preparing the FY 1986 budget. However, within the Critical Engineering Systems Section, the Earthquake Hazard Mitigation Program has been divided into four new subelements which take into account research efforts now successfully completed and the elimination of the Societal Response title as a subelement of this program. These new subelements are intended to emphasize areas of research which are currently most important for earthquake engineering. These program elements and their general objectives are:

SITING AND GEOTECHNICAL SYSTEMS

This addresses the fundamental engineering issues related to earthquake ground motion and estimates the effects of geologic structures, including surface and subsurface soil and rock systems. Primary research areas are Strong Motion Research, Geotechnical Systems Stability, Tsunami Systems Engineering and Lifeline Systems.

STRUCTURAL SYSTEMS

This addresses fundamental engineering issues related to the conversion of basic scientific seismological and ground-motion data into basic engineering seismic loadings: the development of innovative and practical analytic methods to predict the response of contructed systems to earthquakes, the development of basic engineering information of the dynamic resistance of new and existing constructed systems, advances in risk analysis methodology, and the identification and development of test facilities which are important to understanding and predicting the seismic behavior of constructed systems.

ARCHITECTURAL AND MECHANICAL SYSTEMS

This addresses fundamental architectural and mechanical systems which generally comprise portions of structures and facilities which are not taken into account when evaluating the strength and resistance of a structure to earthquake forces. Also included are items such as computers, building contents, mechanical equipment and electrical distribution equipment.

EARTHQUAKE SYSTEMS INTEGRATION

This addresses fundamental engineering issues concerning more effective application of knowledge by engineers, architects, planners, and other practitioners to mitigating, preparing for and recovering from earthquakes. Research supported includes innovative efforts which stimulate the flow of knowledge from knowledge producing-systems to knowledge using-systems.

I would like to highlight a few activities which have been carried on under the NSF Earthquake Hazard Mitigation Program.

Masonary Research.—The large number of buildings constructed from unreinforced masonry are a significant seismic hazard in many parts of the U.S. and in other countries. As only minimal basic engineering studies have ever been carried out under static, let alone dynamic, loading conditions, the knowledge-base for masonry systems is dangerously deficient. Such construction presents a real dilemma. Because masonry construction has been used for perhaps thousands of years, it is generally assumed by the public that we must have a complete knowledge of the behavior of such systems. Unfortunately the knowledge base which has developed is primarily empirical information accumulated over time and this information provides inadequate guidance for extrapolating to different conditions. Thus, in order to assess the potential hazard of unreinforced masonry systems and to develop innovative ways to reinforce and retrofit such systems, an improved understanding of their behavior is needed. A first step in that direction was achieved through an NSF research program which studied unreinforced masonry systems such as might occur in typical low-rise structures. The study was carried under a consortium of investigators (the A-B-K group) formed for the purpose. An interesting outcome of the study was that for a majority of unreinforced masonry structures, horizontal forces due to earthquake motions are transferred through horizontal wood diaphragms (i.e., floor systems), and the knowledge of the horizontal load transfer mechanisms for wood diaphragms was as inadequate as that for masonry. Thus in order to study the masonry problem, a pilot effort on wood diaphragms had to be conducted.

As a first phase in acquiring knowledge, the program has been extremely successful and the knowledge developed has already been incorporated in new methods for the retrofit of certain types of existing unreinforced masonry structures. This new approach provides significant savings over methods previously considered and will simplify the upgrading of unreinforced masonry structures in large areas of the U.S. which face lower-frequency seismic risks. The transfer of this information to those who might benefit from or use such information is being encouraged through support of workshops and conferences.

Learning from disasters.—The NSF has arrangements through the National Academy for Engineering and the Earthquake Engineering Research Institute (EERI), for dispatching investigator teams to areas damaged by natural hazards to capture perishable information that rapidly disappears during rescue and clean-up operations. Such information is absolutely essential for improving the knowledge base for the behavior of constructed facilities under true simulated, loading conditions. This provides verification of computer-based analytic methods and based experimental studies.

In the last few weeks a team was dispatched to Chile to study the effects of an earthquake which caused extensive structural and ground damage on the night of March 3, 1985. This team is a cooperative one involving NAE, EERI and a number of private companies.

Contained Explosive Testing.—Working under NSF support a new method has been developed to simulate earthquake ground motion. The development of the in-place method has the potential to provide a new dimension to our capabilities to test and understand the ground motions, and resulting damage to structures and lifeline systems. This technique can be used for full scale tests under actual conditions. The technique essentially involves producing earthquake like ground motions by simultaneous detonation of a buried array of vertical line sources. The key feature of each line source is a cylindrical tube surrounded by a rubber membrane into which explosive gases are vented. In order to provide verification of the technique, theoretical studies are being made of the ground motions produced by the explosive array and compared to ground motion produced in the near field by large earthquakes. This method, if successful, opens up the possibility of in-place full scale testing at high levels of ground motion, with minimal disturbance to the environment.

Smart Strong-Motion Array.—Although seismological studies provide a basis for establishing the potential frequency of earthquakes and the locations of previous earthquakes, they do not provide one vital piece of engineering information. This is the intensity of the actual strong-ground motion which takes place at or near the surface of the ground at specific points. The picture of ground motion intensities can become quite complex due to modification of transmitted wave energy by variations in soil properties and from reflected, refracted and re-radiated wave energy. Strong-motion measurements made at specific points have increased in number in recent years but the bulk of these measurements are point measurements which do not provide information on the spatial correlation or variation of ground motion over distances of engineering rather than geological interest.

In order to develop improved knowledge of spatial correlations of strong ground motions needed for design of lifeline systems, and in order to establish the probable level of natural variation in local strong ground motions, plans have been developed for a coordinated array of strong-motion instruments which could record such information. In order to optimize the recovery of data it is desirable to place such an array in a rather active earthquake area. Such a site has been found in Taiwan where both an active site and one of interest from a soil mechanics point of view exists. An instrument array known as the "Smart Strong-Motion Array" has been installed on this site. The initial installation is primarily a surface array which is networked together to provide a mini-tomographic (as compared to the crustal studies previously described) picture of strong ground motions over the area of the array. A number of significant strong-ground motions have already been captured by the array.

Future plans are to install "downhole" instrumentation which will provide a third dimension to the data captured by the array. This will provide much better data on the spatial properties of strong ground motion and a better basis for engineering characterization of strong ground motion.

Computer Utilization.—One product of many NSF research programs has been innovative approaches for using computers in the analysis and solution of engineering problems. A strong effort has been made to make these programs available to potential users. Since 1971 the Earthquake Hazards Mitigation Program has supported the National Information Service for Earthquake Engineering. One activity of this service is to make available computer software, developed under public support, which is related to earthquake and natural hazard problems. Although most of the software is not in a "commercial" form, the software presents new concepts and the "cutting edge" of research. Numerous firms, government agencies and other researchers have used this service to obtain new computational developments which are then incorporated into other programs, many of which form new capabilities. As a result of this work a majority of the earthquake engineering computer analysis and software programs in the U.S. and many other countries are based on or influenced by NSF-supported efforts.

Recent advances in computational equipment are making it feasible to carry out analyses which were not previously possible. For example, one recent computer program, COMBAT, developed with NSF support will make it possible to routinely perform 3-dimensional analyses for building structures. The program is now being used and evaluated by a number of groups. There is now a high probability that a users group will be formed to continue development of this important tool without requiring substantial further government support.

International Cooperative Research.—A strong feature of the Earthquake Hazard Mitigation Program is a high level of international cooperation. Such cooperation has synergistic effects in which the sum of the two efforts conducted cooperatively is much more effective than the sum of two individual efforts.

For example, NSF has initiated cooperative research program, in areas around the world which have the highest probability for large earthquakes in the near future. Because of our unique expertise on strong motion instruments and data analysis, we initiated programs to install ground instrumentation and collect strong motion data in earthquake prone areas in Taiwan, PRC, India and Mexico. The results from these dense instrument arrays, as I have mentioned before, have provided a new insight into the ground motion variations and the significance of geological conditions and soil characteristics. Because of these cooperative programs, we now have a better data than in the previous years to verify the predictive analysis results and earthquake engineering evaluations. The data from the Taiwan array on ground motion variations within the land area of typical foundations, lifeline earthquake engineering data from PRC cooperative research, and the comparison of data from digital instruments installed in Mexico are some excellent examples of unique results derived from these cooperative activities for use in the United States.

Similar cooperative endeavors with Japan have resulted in the design, fabrication and testing of large experimental systems for earthquake engineering evaluations of structures built with U.S. and Japan design approaches and specifications.

I would like to review with you future plans for the Earthquake Hazard Mitigation program. As you have already heard, the Program has been restructured to highlight critical areas of research and has been incorporated in a new section of the Engineering Directorate. This is intended to take a more integrated approach toward developing an improved knowledge base for designing, assessing, preserving, upgrading, and enhancing constructed facilities, and toward optimizing performance and life-cycle costs for these facilities.

At the present time we are engaged in an internal systems analysis of the content of the Earthquake Hazard Mitigation research program at NSF. This consists of evaluating the relationship of the individual projects to each other, and to the overall goal of earthquake mitigation.

We also plan an external systems analysis of the Earthquake Hazard Mitigation research program at NSF by an independent contractor. This will evaluate the overall program in relationship to potential hazards, the activities of the other Federal Agencies, and to other natural and man-made hazards that inflict severe losses and suffering on the public. We expect the results to become available within a year.

The results of NSF funded research in earthquake engineering are often important to states and towns as they develop new codes. In order to accelerate the exchange of knowledge between the research community and the user community, we would like to explore plans for establishing a jointly funded research center at a university for the study of mitigation of earthquake hazards. Such a center will also enable the research community to conduct a large coherent project that individual researchers cannot pursue.

One specific item which I would like to mention concerns the Societal Response element as originally presented in the budget.

This element of the Earthquake Hazard Mitigation Program has a number of research accomplishments to show in some of the principal areas of interest.

Mitigation and Preparedness.—We have achieved significant advances in understanding:

The influence of hazard perception on community mitigation preparedness decisions

How seismic building codes and land use plans are adopted

The effectiveness of hazard insurance programs and other types of protection.

Disaster Impacts and Responses.—Major advances have been made in understanding:

Differential impacts of disasters on various population groups such as minorities and the elderly

The nature of community recovery from disaster

Information Dissemination and Warning.—Much has been learned about:

How populations respond to disaster warnings and forecast.

Social and institutional barriers to more effective responses.

There is evidence that both public and private groups are using the knowledge produced by researchers funded by NSF in the area of societal responses. Some of the knowledge produced on mitigation, preparedness, disaster impacts and human responses is now reflected in the plans, procedures, and training programs of the Federal Emergency Management Agency, the American National Red Cross and the

California Seismic Safety Commission. Also results from research on hazard information dissemination and disaster warning have found their way into organizations with warning responsibilities such as the U.S. Geological Survey, the National Oceanic & Atmospheric Administration and the National Association of Broadcasters.

Research in the area of societal response has been redirected and re-focused on the nature of the technology delivery system in earthquake mitigation, on institutional rules and interactions, and on systems integration.

Funding for the Earthquake Hazard Mitigation Program in the Directorate for Engineering will total $17.2M for FY 85. The funding requested for FY 86 is $18.2M which includes $16.4M in the Earthquake Hazard Mitigation Program, $1.3M in other engineering activities applicable to Earthquake Hazard Mitigation, and $.5M in the use of computers for modeling. The funding requested for FY 86 in the AAEO Directorate is $11.0M.

Feasibility studies for future large-scale test facilities needed to answer other earthquake engineering problems will be continued, however these will need to be cost shared and maintained by states that will benefit the most from earthquake hazard mitigation research.

U.S. Earthquake Engineers are among the best in the World. An objective of the Earthquake Hazard Mitigation Program is to continue such scientific and technical leadership through the continued development of fundamental engineering knowledge primarily at U.S. Universities. They have the responsibility of providing the nation with the necessary people trained in the knowledge of earthquake hazard mitigations.

[The following information was subsequently received for the record:]

QUESTION OF THE CHAIRMAN AND THE ANSWERS

Question. In my state of Missouri, we are naturally concerned about the potential for catastrophic earthquakes. Can each of you comment on how your agency has reduced the hazard of a potential earthquake along the New Madrid Fault? What research have you done in this area? And what more should be done under the Earthquake Hazards Reduction Act?

Answer. NSF has not conducted any site-specific geological or engineering research along any of the faulting in the New Madrid area. However, NSF has conducted generic research which is applicable to the reduction of effects of potential earthquakes. These are being done through the Earth Sciences Division and the Directorate of Engineering.

The Earth Science Division conducts generic research in Fundamental Seismological Studies where the research is concentrated on the implications of plate tectonics and the earthquake process. The goal of the earthquake process research is to develop an increased understanding of the physical processes leading to and producing an earthquake such as those experienced in 1811-1812 near New Madrid.

The Engineering Directorate conducts generic research in siting and geotechnical systems, architectural and mechanical systems, structural systems, and earthquake systems integration. The research results are all applicable to the siting, design and construction of facilities in the New Madrid area to resist the effects of earthquakes. Loss of strength of foundation materials by the process of liquefaction occurred during the historic 1811-1812 New Madrid earthquakes. NSF has sponsored most of the research and results in rehabilitation and retrofit of unreinforced masonry structures to resist seismic effects is important to the New Madrid region.

NSF is continuing to conduct generic research in the area stated above. The research is not complete but it is focused toward a better understanding of the causes of earthquakes, better and more economic seismic design processes and methodologies, and increased protection of facilities and lines from the effects of earthquakes.

QUESTION OF SENATOR GORTON AND THE ANSWERS

Question. How serious is the need for a large scale testing facility relative to other uses for the same money elsewhere in the earthquake program?

Answer. Within the earthquake engineering community, there is near unanimity that a need exists for data on the behavior of earthquake—excited full scale of nearly full scale multistory structures from the initiation of structural damage to collapse. To obtain these data in a rapid manner, thus contributing to the improvement of d m and construction of more seismically resistant structures, will require the blishment of a large scale experimental facility. These broad general ions were confirmed by a recent report (1984) prepared by the National earch Council on Earthquake Engineering Facilities and Instrumentation.

Current preliminary estimates indicate the establishment of a large scale experimental facility would require a capital expenditure of at least one magnitude larger than the one-year NSF Earthquake Hazard Mitigation Program budget. Hence, it appears that it is economically impractical to establish a large scale experimental facility using the currently available funds.

Several universities do have strong academic and research programs in Earthquake Hazard Mitigation and NSF continues to support these outstanding programs. These universities also have limited experimental facilities to conduct small to medium scale experiments and NSF actively supports upgrading and expansion of these facilities. NSF expenditures to support these facilities come from the current budget and have been at a level of about ten percent of the budget. We intend to continue this support function.

The lack of a large scale experimental facility has the effect of lengthening the overall schedule to solve many of the problems and issues in Earthquake Hazard Mitigation. Without the large scale facility, research will continue and the earthquake engineering community will necessarily rely on analytic techniques, small and medium scale experimentation, and computer simulation and modeling.

Question. Has any of your "lifeline" engineering research focused on the safety of chemical plants in an earthquake? In the aftermath of Bhopal, could this be viewed as an important problem?

Answer. Research conducted by the Earthquake Hazard Mitigation Program has a direct relationship to chemical plants. The Program subelements are Siting and Geotechnical Systems, Structural Systems, Architectural and Mechanical Systems, and Systems Integration. The research conducted in these subelements are related to specification of ground motion, design methodologies for facilities, performance of facilitation, and transfer of technology to engineers and officials; all of which are considered in good chemical plant design practice. Additionally "lifeline" engineering research is conducted within each subelement.

An example of earthquake engineering research directed toward facilities such as chemical plants is a project being conducted at Stanford University. The subject of this research is "Seismic Risk to Major Industrial Facilities". In this research project, the principal investigators have carefully examined the research results by applying the seismic risk methodology to a large oil refinery which is a complex chemical plant.

Chemical plants also contain and can be part of complex pipeline systems. NSF has sponsored research, through the American Society of Civil Engineers, in the development of "Guidelines for the Seismic Design of Oil and Gas Pipeline Systems". These guidelines represent an important and significant contribution to lifeline research.

NSF views the seismic safety of chemical plans, as well as other industrial facilities, as important safety issues both from a potential for loss of lives and loss of investment and industrial capability. It is our intention to continue to address the issues of seismic safety of industrial facilities as we have in the past to provide the fundamental knowledge necessary for improved design guidelines and methodologies.

QUESTIONS OF SENATOR PRESSLER AND THE ANSWERS

Question. I have been very interested in developing the Continental Scientific Drilling Program (CSDP), in which your agency is involved. I am particularly interested in hearing your thoughts on the extent, if any, to which the specific programs of the Earthquake Hazards Reduction Act efforts could be integrated with the CSDP.

Answer. The study of fault-zones and earthquakes mechanisms is one of the several major objectives of the Foundation's Continental Lithosphere Program which provides the context for the Foundation's activities in continental scientific drilling. Two studies are currently underway to identify promising drilling targets including those where drilling would contribute directly to the understanding of fault-zone structure and earthquake mechanisms. First, the Continental Scientific Drilling Committee (CSDC) of the National Academy of Sciences has nearly finished a report entitled: Downhole Physical Properties Measurements and Fault-Zone Drilling (Staff Officer: Robert Andrews 202-334-3350). This report identifies five sites where drilling would provide critical information relating to earthquake hazards. It also discusses the importance of continuous downhole monitoring of active fault-zones.

Second, a workship is being conducted by Deep Observation and Sampling of Earth's Continental Crust, Inc. (DOSECC) on 29 April-1 May to plan future NSF-sponsored drilling activities. At least six projects related to earthquake hazards will be considered at this meeting (Coordinator: Dr. Edward Schreiber 718-520-7421). Both of these activities (the CSDC report and the DOSECC workshop) are sponsored by the National Science Foundation, the Department of Energy, and the U.S. Geological Survey under the Interagency Accord on Continental Scientific Drilling.

Question. In comparison to other techniques, how effective would continental crust drilling be in achieving the goals of the Earthquake Hazards Reduction Act?

Answer. Drilling will be especially useful for obtaining direct measurements of in-situ stress, pore-pressure, and temperature within activie fault-zones. Such measurements should resolve important questions about the stress levels required to cause earthquake movement and about the role of pore fluids in triggering or facilitiating such movements. Such studies will complement, but not replace, geological, geophysical, and geochemical studies of fault-zones, seismological analysis of earthquake mechanisms and geodetic measurements of crustal strain.

Question. Specifically, what is the probability that an effective CSDP could substantially increase the lead time for earthquake warnings?

Answer. Downhole monitoring of microseismicity, variations in pore-pressure, and other phenomena in or near active fault-zones may eventually prove to be useful in providing advance warnings of future earthquakes, but this has not yet been established, and no specific probability can be assigned to the likelihood of increased lead time.

QUESTIONS OF SENATOR HOLLINGS AND THE ANSWERS

Question. NSF and USGS have spent a considerable amount of money in recent years on geological research related to understanding and predicting earthquakes.

In your judgment, has the investment led to significantly improved scientific knowledge about earthquakes? Are we making progress, even in the difficult area of prediction?

Answer. Within NSF, fundamental research on the nature of earthquakes is supported through the Earth Sciences Division in the Astronomical, Atmospheric, Earth and Ocean Sciences Directorate.

The primary goal of the NSF research involving fundamental earthquake studies is to acquire greater understanding of the fundamentals of the earthquake phenomenon and associated processes. Such an understanding is essential for the eventual prediction of earthquakes and destructive ground motion. These fundamental studies will provide the framework on which more empirical programs of earthquake prediction can be based.

Significant progress has been made in recent years toward a better understanding of the earthquake process as the following list of accomplishments demonstrates:

Delineation of "seismic gaps" and a map of seismic potential for the simple major plate boundaries of the earth;

Increased knowledge of the nature of subduction zone earthquakes and the physical processes by which they are generated;

Better knowledge and understanding of the state and magnitude of stress in the earth's lithosphere;

Evidence that most large plate boundary earthquakes are complex multiple shocks that consist of a number of smaller events;

The association of the location of particular intraplate earthquakes with faults and other tectonic features;

The improved delineation and understanding of lateral heterogeneity in the Earth;

A better understanding of the processes that go on in rocks prior to an earthquake and of the details of the final rupture and energy release;

The introduction of a new, more quantitative measure of the "size" of an earthquake, the moment;

The inverson of seismic data to determine the moment tensor as a function of time—a measure of the temporal pattern of stress release;

The improvement of discrimination between earthquakes and underground nuclear explosions;

Improved procedures to compute synthetic seismograms;

A better understanding of the dynamic processes of faulting—how a fault rupture nucleates, spreads, and finally stops, and the effects seen in seismograms from each of these three stages in the faulting process;

An increased knowledge of the phenomena that occur on a fault within the zone of crushed material;

discovery that a number of major earthquakes have been preceded by a pre-
ry clustering of small earthquake events in their epicentral regions; and
arch on tilt, magnetic field, resistivity and gas emanation, which has fur-
some suggestive, but not universally accepted, precursory data.

tion. As I read your budget, your current fiscal year 1985 spending plan for
uake hazard mitigation is 13.8 percent below what was originally planned for
ar.

has fiscal year 1985 spending been cut so drastically? What previously
d work will now be eliminated?

ver. The Engineering Directorate is making a concentrated effort to leverage
m funds by involving state and local government funds in the Earthquake
l Mitigation Program. Success in this endeavor could increase the total funds
le for Earthquake Hazard Mitigation Research.

der to develop a more integrated program, research on Societal Response has
liminated as a separate program element and has been merged into the other
uake engineering research activities. Some of the Societal Response research
ies have achieved their stated objectives and will be phased out. These include
h on emergency response and reactions to disaster warnings. As significant
develop in the future, they will be given special attention.

tion. In your testimony, you mention that the new Continental Lithosphere
m may have applicability to the earthquake program.

earthquake-related concerns by explicitly part of the mission of the lithos-
program?

ver. Yes, earthquake related concerns will be explicitly a part of the research
ted by the Continental Lithosphere Program as explained below.

nt surveys of the earth sciences by the National Academy of Sciences (NAS),
ng the Commmittee on Science Engineering and Public Policy (COSEPUP)
ch Briefing on the Solid Earth Sciences, have recommended that NSF supple-
ts small grant research programs in earth sciences with selected larger multi-
tional projects aimed at a new and more comprehensive understanding of the
ntal lithosphere—the outer, relatively rigid layer of the earth, approximately
thick, and underlain by less rigid rocks.

sic and more advanced understanding of the earth's lithosphere in general,
e structure and lithology of the crust underlying North America specifically,
result in revolutionary scientific discoveries. These in turn could lead to
hroughs in new energy sources and mineral deposits, responsible methods of
disposal, and advances in prediction of earthquakes and volcanic activity.

sponse to the above recommendation, the Earth Sciences Division has added
program, the Continental Lithosphere Program (CLP), to address projects of
pe envisioned in the NAS reports. In particular, these reports identified a
r of high priority areas for emphasis and several of these are directly applica-
the National Earthquake Hazards Reduction Program (ENHRP). One such
volves seismic investigations of the continental crust. This area includes both
reflection profiling and seismic refraction studies and provides the most de-
information on deep structure. COCORP—the Consortium for Continental Re-
Profiling project at Cornell University featured in previous year's earth-
testimony is an exmaple of a project in this area supported by the CLP.

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eports is the use of modern, digital, wide-band, wide-dynamic-range, seismo-
arrays. Such arrays, linked to computers can provide high-resolution imaging
crust and deeper parts of the lithosphere. They can provide the data needed
rmine the precise location and mechanism of earthquakes anywhere on the
n near real time using satellite telemetry of the data. Modern digital data
the use of sophisticated tomographic techniques (similar to CAT scans in
l science) to map structure (and possibly kinematics) of the lithosphere and
parts of the earth. NSF would be cooperating in this data of research with
S. Geological Survey which operates the current, largely analog, World Wide
rd Seismograph Network. This network has provided very valuable data for
eismological research for the past twenty years.

tion. The cause of U.S. earthquakes east of the Rocky Mountains is not well
tood. Since these taken place in the middle of a crustal plate, they are not
by the usual mechanism of friction between two plates. Yet eastern earth-
pose real hazards to life and property.

t percentage of the Earth Sciences Division's earthquake program is explicit-
oted to research on the "intraplate" processes that cause earthquakes east of
cky Mountains? In light of recent discoveries that eastern earthquakes may
r periodically, will this percentge change in the coming years?

Answer. The Earth Sciences Division supports fundamental investigations of the earthquakes process, and all of this research is in some way relevant to the problem of earthquakes east of the Rocky Mountains.

More specifically, in fiscal year 1984 approximately $3.0 million out of a total program of $8.3 million or 36 percent was explicitly devoted to research on the earthquake process in the Eastern U.S. The future percentage of the program devoted to the study of eastern earthquakes will depend on the importance the seismological community places on this area of research and the number of proposals submitted to NSF for the support of such research.

An important area of research for the future concerning eastern seismicity will certainly be seismic reflection profiling. This is especially true for eastern earthquakes, because east of the Rocky Mountains, faults are often obscured by vegetation and thick sedimentary cover and movement of these faults rarely results in ground breakage. The COCORP (Consortium for Continental Reflection Profiling Project) at Cornell University is an example of a project supported by the Earth Sciences Division whose results are explicitly relevant to eastern seismicity. In several studies, COCORP has obtained reflection profiles in the Southern Appalachians and New England Appalachians, which have revealed buried faults that may have played a role in several large historical eastern earthquakes, for example, the 1886 Charleston earthquake.

For much of eastern North America the instrumental record of earthquakes is quite short, less than 50 years. Nevertheless, the record of felt earthquakes is 250 to 300 years in several areas. Progress is being made in reanalyzing the felt reports from older earthquakes so as to pinpoint the locations of those older shocks, estimate their magnitudes, and provide estimates of the energy released. Within the next 10 years these techniques, coupled with seismological exploration techniques like reflection profiling for determining geological structures responsible for eastern earthquakes, should begin to provide reliable estimates of recurrence intervals and the long-term hazards for this region.

Question. NSF now helps support an important library of earthquake documents, based in Berkeley, California. As valuable as this library is, it is difficult for eastern researchers to reach.

Are there any plans to help fund a second earthquake library in a place more accessible to eastern researchers and officials?

Answer. The National Information Service for Earthquake Engineering is working on plans to make itself more visible and accessible to eastern researchers and officials. This is reflected in the fact that there is eastern representation on its National Advisory Commmittee. Also its documents, such as the Abstract Journal, are available by mail throughout the country and it is convenient for persons located anywhere to subscribe to its computer software service.

There are no plans to fund a new library at this time. However, as in the past, we will consider, based on availability of funds, and appropriately evaluate any unsolicited proposals submitted to help establish such an information service.

Question. You are cutting the societal response element of your earthquake engineering program.

Exactly how much are you reduicng this activity, what is being phased out, and why do you feel that this element is no longer as important as before?

Answer. Societal Response, which has a budget of $.9 million in fiscal year 1985, will be phased out as a separate budget entity in fiscal year 1986. Significant activities that would have been supported under this element, such as information dissemination, will now be supported in the Earthquake Systems Integration component of the Earthquake Hazard Mitigation Program. These activities are as important as before and curtailments because of limited resources will occur only in those areas where much has already been learned. These areas include research on emergency response and reactions to disaster warnings.

Senator GORTON. Thank you, Dr. Suh.

Mr. Kammer, you and I seem to be the only nonscientists here today. That is not the reason you were left for last.

Mr. KAMMER. Thank you, sir. My name is Ray Kammer. I am the Deputy Director of the National Bureau of Standards, and I am here to discuss the earthquake hazard reduction activities of NBS. These activities are conducted in the Center for Building Technology.

The proposed NBS budget for fiscal year 1986 includes some very significant program changes amounting to about $33 million out of a budget of $120 million; about $16.5 million in increases and about $16.5 million in decreases for the programs.

One of the decreases proposed is the termination of the Center for Building Technology.

Senator GORTON. Please get a little closer to the microphone so I can hear you.

Mr. KAMMER. One of the decreases we propose is the termination of the Center for Building Technology. This would include stopping the NBS efforts of earthquake reduction. This action is included in this budget for two reasons. First of all, to allow NBS to undertake new programs addressing critical new technologies without increasing our budget; and second, to implement the administration's policy of disengaging the Federal Government from areas in which State and local governments have primary responsibility. Building and safety codes have traditionally been within the purview of State and local governments.

This concludes my statement, Mr. Chairman.

Senator GORTON. Mr. Kammer, I think I will start the questions with you. Do you have any evidence that either State and local governments on one side or the private construction industry on the other side is able or willing to take over the role of the Center for Building Technology?

Mr. KAMMER. Well, if I may, I will make two comments. First of all, people very seldom volunteer to take on such an obligation if they have a choice in the matter. No people have pressed forward.

Second, there has been some activity in the private sector. The Building Seismic Safety Council that was mentioned in earlier testimony is in the private sector, and it is developing, in fact, building codes and practices for use by the private sector for buildings that are more earthquake resistant. So there is some possibility.

Senator GORTON. How does it compare in size and scope with the NBS Center for Building Technology?

Mr. KAMMER. Well, the entire Center for Building Technology is approximately $12.5 million. The part of the center that works on earthquake hazard reduction is approximately $1.3 million, of which $475,000 is directly appropriated, and $800,000 is provided by a combination of FEMA and NSF.

The Building Seismic Safety Council is essentially a voluntary group with effort provided by people who participate in it. I would not think that the dollar amount was large.

Senator GORTON. Dr. Suh, in your statement you discuss the cutback and the redirection of the societal response research. The 5-year plan for the earthquake program describes several areas in which societal response research was needed. What has changed, if anything, since the 5-year plan was released in January?

Dr. SUH. Senator Gorton, in our restructuring of the engineering directorate we have eliminated societal response as a separate program element. However, many of the issues related to societal response will be pursued within the restructured program; and we will support research that deals with technology transfer, information dissemination and research that has implications for the economic, societal and political areas by incorporating them as part of the earthquake systems integration subelement of the Earthquake Hazards Mitigation Program.

So in some ways we have eliminated as a separate element of the research program some program titles supported in the past. But we feel that one of the best ways of making sure we understand the implications of NSF-supported research is by incorporating some of these things as a more integrated part of our overall research program.

We now have four different subelements within our Earthquake Hazard Mitigation Program. One of these is called the Earthquake Systems Integration Program. It deals with a broad range of systems integration issues. And that program deals with all aspects of technology transfer, information dissemination and the consequence of technological breakthroughs on the associated problems.

Senator GORTON. Do you have any initial results from the team that went to Chile to investigate the recent earthquake there? And particularly, can you tell us what the performance was of modern buildings designed to resist earthquake damage?

Dr. SUH. No, sir. We don't have any inputs yet. We are eagerly waiting for the inputs, and hopefully, we will find out something from them.

Senator GORTON. Will you communicate with the committee when you have something that would be of help to us?

Dr. SUH. Yes, sir.

Senator GORTON. Is most of the earthquake engineering research that NSF funds at universities in the Western United States? Do you believe that the engineering research in universities adequately trains people, if that is the case, for the rest of the country?

Dr. SUH. Well, obviously the issues may be different. For example, in the eastern seaboard we do not have as much understanding of what kind of Earth crust motion will result in earthquakes, and we really have not had much information on the things that could happen along the eastern seaboard. We need to do much more. However, the basic generic things they learn in schools, the basic results of those kind of research I am sure will be applicable in all areas. However, we are very concerned about the fact that some of the research we are doing may not be addressing some of the particular problems that may arise in other parts of the Nation. So we hope to have more workshops and conferences to address all these issues.

Senator GORTON. Thank you, Dr. Suh.

Dr. Peck, not only my prepared work here but my fuzzy memory of my college geology causes me to think that the geology of my home area in the Pacific Northwest is not dissimilar from that of Chile, and as a consequence, earthquakes of a magnitude we recently saw in Chile are at least within the realm of possibility in the Pacific Northwest.

Is there any ability at this point to predict that there would be a similar hazard with respect to California and an earthquake of that degree of seriousness in the next three decades in the Northwest?

Dr. PECK. To my knowledge not, Senator. As you say, the situation is similar to that of Chile in that there is underthrusting of the Pacific plate under Washington, and the continent is overriding part of the Pacific Ocean floor. Historically, there have been ge magnitude earthquakes in the Puget Sound area of magni- le of 6 or 7, with a recurrence interval of 1 or 2 decades.

. think there is some debate about the potential for a very large :thquake, and some scientists believe indeed there is a potential ' a magnitude 7 or 8 earthquake in the Puget Sound area. I do t think we understand the seismic situation in western Washing- ı State as well as we do that in Chile or along the San Andreas ılt in California.

Senator GORTON. Thank you.

With the cuts in the USGS funds for fiscal year 1986 what activi- s will you not be able to accomplish in 1986 that you would be le to do if you had level funding with that of 1985?

Dr. PECK. Well, our 1985 budget was augmented through action Congress by several million dollars, and much of those funds we ed for the acquisition of equipment, for satellite relay equipment .d stress measuring equipment to put in bore holes along the ılt, and the emplacement of those along the fault. So that with e dropback in funds, we will be able to continue to operate that uipment.

We will have to make some cutbacks in the seismograph net- rks, about a 10-percent cutback. We will achieve that by cutting t stations that seem less essential and focusing our efforts more several areas.

ls with many programs in many agencies at this stage, Senator, means a stretching out of the activities because of the con- ained budgets.

enator GORTON. Let us go back to prediction. If the large earth- ıke expected on the southern San Andreas fault would occur, a year from now, how likely is it that we will have some kind hort-term warning like they had in China?

r. PECK. Well, I think it unlikely, but at this stage, if you would mit me, I would like to turn to Dr. Filson, who could give you a more knowledgeable answer.

r. FILSON. Sir, my name is John Filson. I am Chief of the Office Earthquakes, Volcanoes and Engineering in the Geological vey.

'ou have to understand that the area we are trying to monitor California is about 400–500 kilometers long (about 300 miles) n the San Diego region up to the San Francisco region. Current- we are trying to focus our earthquake prediction activities in ifornia in those regions we think most likely to have an earth- ke in the near future.

. particularly interesting experiment is going on in central Cali- ıia near Parkfield where we think there is a high likelihood of a gnitude 6 or so earthquake in the next few years.

o the answer to your question has a geographic twist to it. In se regions where we are focusing our monitoring activities I ık our chances are higher, obviously, than in those regions ere we are not concentrating our efforts. If earthquakes are pre- table, I think our chances of predicting the Parkfield earth- ıke will be high. But the question remains, are all earthquakes dictable, and we do not know the answer to that question yet.

Senator GORTON. Thank you.

How complete a picture, Dr. Peck, do we have of the seismic risk in the central and eastern parts of the United States? Are there areas where there could be a potential for a large earthquake of which we are completely unaware just because there has not been one in the last 100, 200, or 300 years?

Dr. PECK. Well, again, we have a good deal to learn about earthquakes in the Eastern United States. We have a couple of posters with us that will perhaps help illustrate the answers to the question, if I may show them.

We have been focusing our efforts first in the New Madrid area, Mississippi Valley in the Central United States, and in the Charleston area, where there were major historic earthquakes. And we have learned a lot about the mechanisms that caused the New Madrid earthquake and some idea of the recurrence interval.

What Dr. Filson is putting up here is a map showing in red the New Madrid earthquakes of 1811–12, and the Charleston earthquake of 1886. And then, in blue and green, smaller earthquakes and showing their distribution around the Eastern United States.

One of the problems in estimating the future occurrence of earthquakes along the Eastern seaboard, for example, is that in spite of our studies, supported in part by the Nuclear Regulatory Commission, we still do not know the causative mechanism of the Charleston earthquake. We have learned recently from some studies of ancient sand blows phenomena which occur during an earthquake, that there has been three or four earthquakes over the last 20,000 or 30,000 years in Charleston; so it is a recurring phenomena, not just a one-time event.

Without similar detailed studies elsewhere on the Eastern seaboard, we really do not know what the likelihood of an earthquake would be. There have been historic earthquakes up near Boston and up along the St. Lawrence which indicate that there is some likelihood of future earthquakes there. We have a lot more to learn.

Senator GORTON. Thank you.

Now, Dr. Speck, with respect to aiding States and local communities in preparing for earthquakes, how does FEMA ensure that the States are getting the maximum benefit out of limited Federal dollars?

Mr. SPECK. Mr. Chairman and members of the committee, we seek to do that in a number of ways. I do not know that you can always assure that that happens, because that is a reciprocity process. We seek to do it through workshops in which the State and local governments are involved. We seek to do it through contracting with State and local governments such as in the Central U.S. Earthquake Project or in the Southern California Earthquake Preparedness Project, SCEPP. We do it through national programs that are under the leadership of regional groupings.

What I am bottom line saying is that there is a great deal of interaction between the private and academic centers of expertise and the State and local governments and FEMA to try to make certain that what is being prepared there truly does meet the perceived needs of all those groups.

Senator GORTON. How do you plan to test the national response plan for earthquakes?

Mr. SPECK. Mr. Chairman and members of the committee, a plan which involves a number of Federal agencies was exercised by table top this past spring, and we had a number of what you would call controllers to see if it seemed to be a good plan, as it were. We are now in the process of working with the State of California and through the State with local communities in California so that we will be tying the national plan to the exercise that the local governments are having in conjunction with the State in April.

And that national plan will be exercised between the region and the State in June of this year. It will be reviewed by all of the agencies that were involved, as well as the State, to see how the plan itself seemed to work as a plan and where the inadequacies in the operational side of carrying it out appeared to be.

On the basis of that we will go back and hopefully have a final draft plan which we will then move to exercise in other areas of the country as well.

Senator GORTON. One of the recommendations of the independent review panel was that FEMA establish an independent advisory committee for the Agency. Is FEMA in the process of considering that recommendation, or has it made a decision?

Mr. SPECK. We are in the process of considering that recommendation on what the best approach for an ongoing advisory panel would be.

Senator GORTON. Thank you, gentlemen. I have more questions for each of you, which in the interest of time I will submit to you in writing and ask for your prompt response.

Senator Danforth also has a series of questions primarily relating to New Madrid and Missouri. Dr. Peck answered them in part at least in connection with one of my questions; but he will be submitting some to you as well.

We now are delighted to have with us someone who I suspect has an interest in that same question, Senator Gore. The panel is open to you for questions.

Senator GORE. Thank you very much.

The statement focuses on Eastern earthquakes. As a member of the House Science and Technology Committee, over the last several years I have held a couple of hearings about Eastern earthquakes, not because of any lack of concern about earthquakes in the Western United States, but rather because I worry that not enough attention is being given to Eastern earthquakes in my State; and I will elaborate on that.

Mr. Chairman, I would also like to ask unanimous consent to include by reference in the record an article just published by Memphis magazine and entitled "Living on the Fault Line."[1]

New Madrid is the correct pronunciation according to those of us who live in Tennessee and the boot heel of Missouri.

Correct me if I am wrong, but the energy released from the New Madrid quakes of 1811 and 1812 equaled or was greater than the energy released in all other earthquakes in the Continental United States combined in recorded history. That is correct, is it not?

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[1] Article from Memphis, Vol. 9 No. 11, Mar. 1985, p. 36.

Dr. **Peck.** For that answer I need to refer to my earthquake experts.

What do you say, John?

Dr. **Filson.** My name is John Filson. I am the Chief of the Office of Earthquakes, Volcanoes, and Engineering.

Senator, it may be close. The reports are three magnitude 8 earthquakes or greater in the New Madrid area within a few months in 1811 and 1812. I cannot do the calculation in my head right now, but given what I know about energy release, the statement sounds a little—causes me to pause.

But it may be correct. I would have to check.

Dr. **Peck.** Of course, one spectacular thing is the area of disturbance and strong ground shaking caused by that earthquake.

Senator **Gore.** Well, that is because the rock is much denser in the Eastern part of the United States and the energy travels over a much farther distance. The combination of the enormous energy involved in those three quakes and the underlying geology creates the pattern that your graph shows there.

And if you have a recurrence of a quake like that, with the amount of construction and development that has taken place in the last 150 years or a little longer, then obviously you can see that the amount of damage done is much larger than that which would accompany a quake in the Western United States. That really argues for a little more attention being given to preparedness for Eastern quakes.

Church bells rang in Boston from that quake in New Madrid. The pronunciation is New Madrid, and you have got to get that straight. It is near Cairo, you know.

Dr. **Peck.** Thank you, Senator.

Senator **Gore.** Anyway, thank you for your response on that. I want to apologize for having to leave so soon after my questions. I am deeply involved in this MX debate on the floor, and I hope that the chairman will forgive me for that.

I am told that is rather commonplace over here on this side, to come in and go out.

Senator **Gorton.** It is, and the chairman would like to get down there in time to read a brief statement.

Senator **Gore.** Well, I will be very brief myself.

Let me ask a question to Dr. Speck of FEMA. There was a 5-year program plan for the National Earthquake Hazard Reduction Program that was mandated to be given to the Congress in 1981. Why was the 5-year plan 4 years late?

Mr. **Speck.** Mr. Chairman and members of the committee, I do not know that it was 5 years late in the sense that the request was in 1981 that it be developed, and I am not certain it was certain at that time exactly how long it would take. But there was certainly the desire that it get here a lot sooner than January 4, 1985.

Senator **Gore.** No, no. It was due in 1981.

Mr. **Speck.** The delay I think was a function of a number of things. First, to create a plan you had to conceptualize things that had never before been conceptualized. It was not simply pulling bits and pieces off the shelf and tacking them together and saying here is your plan.

It required looking at the state of methodology for a risk assessment and a whole series of things to see where we were and where we needed to go in the development of that kind of plan. It required the coordination of a number of Federal agencies in that process. That was done, and then a national panel, a review panel, was selected and asked to look at it, and it took a number of months for them to also review it.

They came back with essentially two levels of funding—a higher level and a lesser level. And as we looked at what we needed to do with that it took time to assimilate that.

Senator GORE. Now everything you have talked about so far was completed in March 1983. What happened for the last 2 years?

Mr. SPECK. Well, I do not know that the completion of all elements of the plan as a result of the obtaining the results of the review panel was completed at that timeframe. When I came on, at the very end of 1983, we were finalizing that. At that point we had to then give OMB an opportunity to look at the plan, and that was a fairly lengthy process as well.

Senator GORE. So OMB let it sit over there for 2 years basically? That is what happened then?

Mr. SPECK. No. You are putting words in my mouth that are not accurate.

Senator GORE. Well, I am not trying to attribute those words to you. I am asking you whether or not OMB took 2 years to review it.

Mr. SPECK. The plan went to OMB in essentially mid-1984, the spring of 1984, as I recall, for review, and there was a good deal of discussion over a period of time in that regard.

Senator GORE. I thought the draft went to them in 1983.

Mr. SPECK. Not to my recollection, but I can check that out for you.

Senator GORE. I would appreciate that.

Mr. SPECK. I know I spent some time back and forth trying to hurry that process up. And there was also finally getting everybody to write off on it.

Senator GORE. Which of the earthquake experts at OMB reviewed it?

Mr. SPECK. Mr. Chairman and Senator Gore, I am certain that OMB would be pleased to have the opportunity to respond to that.

Senator GORE. I do not share your certainty, but let me move on. If you want to supplement that for the record, please do. I do not want to be impolite if you are not finished.

[The following information was subsequently received for the record:]

The Steinbrugge Panel formally submitted its recommended Plan to FEMA on June 9, 1983. Following a thorough and coordinated review among the three other principal agencies assigned responsibilities under the National Earthquake Hazards Reduction Program (U.S. Geological Survey, National Science Foundation and National Bureau of Standards), FEMA concurred in and provided to the Office of Management and Budget for the first time the Steinbrugge version of the Plan in July 1983. During the next 18 months, considerable interaction between OMB, FEMA and the other three principal agencies was required to adjust the Steinbrugge version into a final Plan which effectively addresses the nation's earthquake hazard but within funding levels established by the Administration's deficit reduction initiatives. This delay should not be regarded as a lack of support for the National Earthquake Hazards Reduction Program (NEHRP), but rather a careful and deliber-

ate effort by the Administration to balance the importance of the nation's earthquake hazard reduction activities against the overwhelming need to reduce the Federal Budget deficit.

Senator GORE. Now in 1984 FEMA and the National Academy of Sciences recommended further analysis of a full-scale earthquake testing facility. Has that analysis been completed?

Mr. SPECK. We have received analysis on that, yes. I think there is additional work to be done, and that is before the Policy Coordinating Committee of the NEHRD at this time.

That issue was taken up at the last meeting and it is anticipated that it will be taken up again at the May meeting to determine whether or not it is appropriate to go ahead, because there are a number of issues involved. One of the issues obviously is whether it would be nice to have, whether there would be useful if not critical outputs from such a facility.

The other issue is whether or not you can finance such a facility, whether there will be such a sufficient number of users to fund the very substantial overhead of such a facility. That was the issue raised at the last Policy Coordinating Committee. That is one that is being reviewed.

That is one that is going to receive attention as a major item on the agenda at the next committee, because I think you find in a number of things where you make a capital investment and do not look carefully enough at the operating costs that is what is being reviewed at this point.

Senator GORE. OK. Now the Center for Building Technology at NBS that the chairman asked about earlier contains the Government's top experts on the effect of earthquakes on manmade structures. What assistance does the Center for Building Technology provide to FEMA in terms of help with model codes and help in judging the technical merit of contractor proposals submitted to FEMA?

Mr. SPECK. Mr. Chairman and Senator Gore, we have had a very close relationship with the NBS and the Center of Building Standards has been under contract to FEMA to provide a number of services, to oversee the technical aspects of the ABE joint venture which I described in my testimony. As we look at lifelines to oversee the work of the Building Seismic Safety Council as it has been developing standards for non-Federal buildings, and to supervise the Interagency Coordinating Committee on Seismic Safety Construction for the mitigation work that they have been doing.

Those would be some of the principal areas on which we have looked to the NBS to provide expertise.

Senator GORE. Now it appears to me that FEMA's small earthquake program staff does not appear to have the same technical skills as the staff of the Center for Building Technologies. Am I correct on that?

Mr. SPECK. Mr. Chairman, in respect to this particular area of expertise, I think that is very true.

Senator GORE. OK. So does this mean that if the Center for Building Technology were abolished FEMA would have to contract out for the technical services now provided by the Center for Building Technology?

Mr. SPECK. Mr. Chairman and Senator Gore, I would anticipate that FEMA would certainly have to contract out for a major part of those services.

Senator GORE. What would that cost? Do you have any idea in terms of consulting fees and administrative costs to process the paperwork associated with consultants?

Mr. SPECK. Mr. Chairman and Senator Gore, I cannot give you a figure at this time. I think that we probably would be putting that out to bid, and it would be difficult to project. I do not know that Government is necessarily any less costly when it provides a service. It might be fair that insofar as cost is concerned we would be in the same ballpark.

Senator GORE. So we might not save anything at all by eliminating the Center for Building Technology?

Well, Mr. Chairman, I have a number of other questions that I would like to submit in writing for the record, if these witnesses and the ones to follow would be kind enough to respond. In order to assist the pace of the hearing, I will just ask for those in writing. I appreciate your courtesy.

Senator GORTON. Thank you. They will be submitted in writing. We also are notified that Senator Pressler has submitted some questions as well.

With that, I should like to thank all four of you for your enlightening testimony and for your help to the subcommittee.

We will now hear from Mr. Fowler, the director of the Washington State Department of Emergency Management, and Dr. Charles Lindbergh, of the Department of Civil Engineering, at the Citadel in Charleston.

Mr. Fowler, your written statement, which is before us, will be printed in the record and you may proceed, and it would help us if you could summarize it.

STATEMENTS OF HUGH F. FOWLER, DIRCTOR, WASHINGTON STATE DEPARTMENT OF EMERGENCY MANAGEMENT; AND DR. CHARLES LINDBERGH, DEPARTMENT OF CIVIL ENGINEERING, THE CITADEL, CHARLESTON, SC

Mr. FOWLER. Thank you, Mr. Chairman.

I am Hugh Fowler, director of the Washington State Department of Emergency Management. I appear before you today to support the National Earthquake Hazards Reduction Program.

The elements of the proposed program are:

One, to gather information needed to better understand the earthquake hazard in various ares of our Nation;

Two, to develop techniques to predict when and where earthquakes will occur;

Three, to develop a better understanding of the impact of ground motion on buildings and ways to lessen the impact;

Four, to increase public awareness of earthquake hazards and to encourage and assist local governments and the public to take appropriate preparedness and response actions; and

Five, to conduct fundamental studies in order to better understand earthquakes causes and effects.

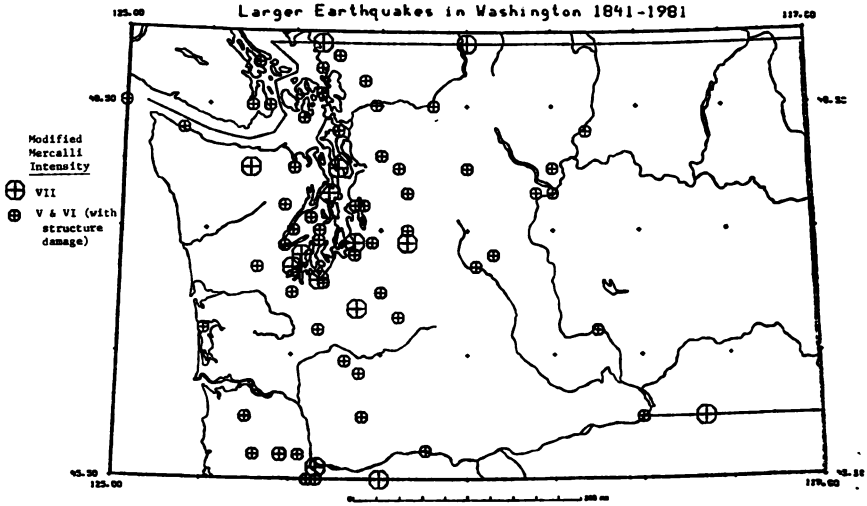
Each of the five program elements which are included in the proposed program will help reduce loss of life, injury, property damage, and economic impact that would result from a major earthquake.

As an emergency manager, my responsibilities rest primarily with element 4, which is pointed at increasing public awareness and promoting preparedness and response actions at the State and local level. Many States, including Washington, have adopted comprehensive emergency management in recent years. Comprehensive emergency management comprises four phases—mitigation, preparedness, recovery, and response actions.

From my point of view, the Earthquake Hazards Reduction Program contributes measurably and directly to the mitigation and preparedness phases. Continuation of the program will pay dividends in terms of preventing deaths and injuries and reducing damage or loss of property.

Washington State has a history of frequency seismic activity. Since 1840 there have been over 1,000 earthquakes strong enough to be felt within the State. Fourteen were felt over a large part of the State. Most of these major earthquakes have occurred in the Puget Sound region, where 60 percent of the State's population lives.

Below is a sheet that shows the concentration within the Puget Sound area. Puget Sound's most recent damaging earthquakes occurred in 1949 and 1965. Seismic history and scientific evidence show that another major earthquake will occur. It is not a question of if, but, rather, when.


Larger Earthquakes in Washington 1841-1981

University of Washington

A 1975 U.S. Geological Survey report titled "A Study of Earthquake Losses in the Puget Sound, Washington, Area" projects that an earthquake of 7.5 magnitude under the worst conditions could cause as many as 2,200 deaths and 8,700 injuries. Furthermore, it is possible that over 23,000 people would be homeless and would require temporary shelter. Those figures, Mr. Chairman, are based on 1970 census data and would be somewhat higher based upon today's population.

Since assuming my present responsibilities in 1981, I have been asked are the State and its local governments prepared to respond to such a catastrophe. And my answer has been no. A major earthquake in the Puget Sound basin similar to the one in 1983 that occurred in southeastern Idaho is the most severe natural hazard we face in the State, from the standpoint of impact on people and property.

In 1981, the State began participating in a federally funded earthquake preparedness program administered by the Federal Emergency Management Agency. Our accomplishments during the past 4 years include public and organizational awareness. This is really the first step to approaching and reaching what might be considered a full state of preparedness.

You have got to inform people, industry, the public, the Government officials and so on that there is in fact a hazard, and we have made a great deal of headway in that area.

Instilling earthquake awareness has been a continuous process. State and local officials, private agencies, and scientists and seismologists provide personal preparedness and technical information and conduct briefings whenever and wherever possible to people of all ages, walks of life, and employment. The amount of written material available such as technical papers, reports, books and informational brochures and pamphlets from all the above enhances the ability of State and local government to increase awareness of the impact of earthquakes.

We have also made headway in terms of planning, writing plans for such an event. We have a generic State plan that addresses the earthquake hazard as well as other types of hazards that we experience. At the present time, we are concentrating on mass casualty planning, recognizing that there are so many things to be done that you can spread what resources that you have too thin, and we feel that when this happens that the emergency response immediately following the event is perhaps the most important—taking care of the injured and the lifelines.

Development is progressing on triage procedures; critical/vital equipment and supplies for hospitals, morgues, and transportation. In addition criteria is being developed for selection and operation of alternate treatment sites.

Increasing numbers of local governments and organizations, as well as those at the State level, are conducting earthquake exercises and training. The available earthquake data and increased awareness of the severity of this hazard has stimulated planning, exercising and training activities.

Computer applications are being developed for use in determining earthquake damage, vulnerability, preparing response plans, and exercise scenarios evaluating response and resource allocation decisions and researching mitigation strategies.

Development of monitoring, prediction, and mitigation capabilities is progressing. Earthquake monitoring is currently being done by 114 seismograph stations in Washington and northern Oregon.

Much of this equipment has been installed in recent years. Monitoring and research activities are performed by the University of Washington and funded by the U.S. Geological Survey and U.S. Department of Energy. Analysis of this data provides timely information on earthquakes, as well as information to develop models of causes of earthquakes in the Pacific Northwest. This is valuable historical and risk analysis data.

School earthquake prototype studies and education programs are being developed, and significant local actions have occurred to address the need for earthquake mitigation activities. I believe that Dr. Speck exhibited a product from that particular action.

Public school districts are forming earthquake safety committees to determine appropriate policies, obtain safety equipment, supplies, and equipment for each school district building, and suggest appropriate staff and student training. And this is extremely important too.

The Washington State Legislature is presently considering two bills concerning seismic safety. One would establish seismic resistance codes for existing unreinforced masonry school buildings, and we have a number of those that were identified in the 1975 USGS study.

The other piece of legislation would establish a State seismic safety commission similar to the State of California's, and I am particularly excited about this because in working with our legislature it is a case of creating an awareness, stimulating an interest on really how bad this problem is.

The funding assistance received from FEMA in recent years has enabled my State to begin this vital preparedness effort, and I might say that without it we would not be nearly where we are. However, much more needs to be done before we can revert to a maintenance posture.

In reviewing the fiscal year 1986 budget, I note that element 4, preparedness planning and hazard awareness, would receive 6 percent of the total funding, in other words a little over $4 million of the $69 million. Planning funds for the Puget Sound area would be reduced from $125,000 in fiscal year 1985 to $50,000 in fiscal year 1986 under the proposal. The proposed amount is not adequate to perform those actions necessary to continue the initiative began during the past 4 years.

In summary, Mr. Chairman, the earthquake hazard in Washington State is the most serious natural threat we face. In view of the historical and scientific evidence that a major earthquake will occur, much more is required to reach an acceptable level of preparedness to ensure the best possible response.

A reduction in earthquake preparedness funds would virtually bring to a halt any significant efforts to prepare for earthquakes and minimize their impact. Without such preparation, response and recovery from a major earthquake would be monumental, with staggering human and economic costs and losses. By necessity, most of the recovery costs would be borne by the Federal Government.

On the other hand, continuation of the Federal earthquake funding at an adequate level will reduce loss of life, injury, and damage to property when a major earthquake occurs in my State.

That concludes my statement, Mr. Chairman.

Senator GORTON. Thank you, Mr. Fowler.

Dr. Lingbergh, your own Senator, who is a member of this committee, Senator Hollings, has asked that an opening statement be included in the record, which it will be, and he has some questions which we will submit to you in writing.

We have this monograph on your views, which will be included in the record, and for which we thank you. I will accept such informal comments as you would like to make.

Dr. LINDBERGH. Thank you very much.

Senator GORTON. Why don't you get a little closer to that microphone, sir?

Dr. LINDBERGH. Mr. Chairman, it is my distinct privilege and pleasure, sir, to appear before this distinguished committee on behalf of our public in the Southeastern United States. I speak, sir, as the cochairman of the South Carolina Seismic Safety Consortium, and also the cochairman of the Southeastern United States Seismic Safety Consortium.

With your permission, sir, I would like to with my testimony, written testimony, being accepted for the record, speak from the floor, sir.

Senator GORTON. Fine.

[Slides are shown]

Dr. LINDBERGH. I trust, sir, this is focused all right.

As an overview, sir, I would just like to capsulize our understanding of the seismic threat to the Southeastern United States, centering in particular on the great Charleston earthquakes, and I intentionally have used the plural of earthquake—I will later discuss the reason for that—overview the current state of total vulnerability of our region to the seismic threat; look at the seismic safety needs in our region; and examine certain ongoing program initiatives; and then conclude.

We have already had, particularly by Senator Gore, good emphasis placed on the differences between our Eastern and Western earthquakes. On the ones in the East, we know that when they occur they cause far more devastation. They particularly would today with the greater population and industrialization of these regions.

Second, we know, however, that they do occur less frequently than their Western counterparts. This essential difference is that which has strongly influenced the safety posture—the relative safety posture—between the Eastern and Western regions. It has led to complacency in the Southeastern United States, and it has led to the greater growth in seismic safety and technology in the Western regions. The principal results that today we are decades behind our Western counterparts in regards to seismic safety posture.

Dr. Nuttli, one of our noted geophysicists, has illustrated very well the dramatic levels of destruction and lives lost that could occur due to the next great earthquake in the East.

I would like to take you back, sir, to Charleston of 1886, if I may. The peninsula area of Charleston, bordered by the Cooper River and the Ashley River.

These are the isoseismales of the event, Charleston being here with a peak intensity of 10. The influence was felt as far as 800 miles away, as was previously discussed.

Walking through the city of Charleston.

Unreinforced masonry buildings. Most of these are still in Charleston in a restored state. This is where in 1986, the U.S. Third Earthquake Engineering Conference will be held, in August of 1986, Hibernia Hall.

A photograph of the Charleston Port Society building 2 days before the earthquake.

And this was the postearthquake scene.

East Bay Street.

Homes were ravaged. Refugees from the falling building debris.

A typical home, with the walls damaged.

Now this building is much the same. But this is in technicolor, so obviously it was not in 1886. I went to Coalinga, CA, in May 2 years ago, and took these photographs. I quickly show them here just to show the great similarity in the hazards these unreinforced masonry buildings do face.

I was very distraught to know that the center section of that city of over 10,000 people was damaged to the point that all of these reinforced buildings were being totally demolished.

It was easy to see how this could be Charleston or some other eastern or southeastern city today.

Now we come to the cause of still greater concern. As previously indicated by the U.S. Geological Survey, current—recent investigations—I am speaking now of results that are no more than 30 days old—USGS field investigations around the Charleston area, funded by the U.S. Nuclear Regulatory Agency, have confirmed that there have been at least four great quakes prior to the 1886 event, not within the previous 50,000 or 100,000 years, but, according to their carbon 14 dating procedures, within the last 7,500 years.

And these are just the ones that have been detected. We are satisfied that these results indicate that serious studies are now being conducted to the benefit of our communities in the Southeast. But we are concerned, too, because we see the threat now as even greater than we perceived it several months ago.

The situation throughout the Southeast can be described very accurately, I believe, by this statement of the director of the our COG for the Berkeley/Dorchester Counties in the Charleston area. He says:

> Personally, I believe that most people in this region are aware of the fact that a major earthquake could occur at any time. I do not believe that they are aware of either the possible damages that could occur as a result of a major episode, or what may be done to mitigate the damages.

That is true, sir, I believe, throughout much of the southeastern United States.

Our baseline need is twofold. It is not only to achieve public policy but, more fundamentally, we need to establish in the East and Southeast in particular an adequate baseline of technology, knowledge, and capability among our engineers and technical community. We have not participated in the growth of national technology. Seismic technology, workshops, and references transferred to our communities are not enough. We have to be engaged in the evolution of the technology.

And until we establish this sensible technology base with the help of our colleagues in the Federal agencies and other national regions on the western coast, for example, we will never be able to achieve the public policy that is so urgently needed today.

What we are doing today? We have established our consortiums. South Carolina is the most active now, and it is serving as a prototype for those in the other regions of the Southeast. We have an ad hoc organization of the southeastern U.S. seismic safety consortiums, including representatives from Tennessee, Georgia, North Carolina, Virginia, and South Carolina, who are working collectively in the development of the South Carolina consortium so we can propagate and represent well—technically too—the interests of our public in the southeastern United States and grow sensible seismic safety policy.

Objectives of our consortium—safety policy, technical base throughout the Southeast, and to see that the technology needs are met that are more unique to the Southeast.

We also are looking at wind and the multihazard aspect. We have many hurricanes. This little cartoon I found very interesting in our local paper.

The program plan. It all began, our current technology awareness program, seismic safety program, with the first major engineering conference held in the eastern United States in Knoxville, TN, in 1981. Our consortium organization was born at that time under the great influence of Dr. Walter Hayes of the U.S. Geological Survey, a man whom we deeply respect in our area for his competence and his dedication to his purpose.

And then we are in this current phase now of transferring technology and experience from primarily our western coast and Utah friends and colleagues into our community. And then, so we can advance into the formal State commissions throughout the Southeast, seismic sensible codes and other benefits.

We see here the schedule 1986, next year, of the U.S. Third National Earthquake Engineering Conference. This will be the first major engineering conference in South Carolina, and the first earthquake engineering conference. We hope at that time to be able to announce our South Carolina Seismic Safety Commission and also to adopt for the first time codes for the strengthening of existing reinforced buildings.

These just list the transfer sessions that we have been going through, sir, and we have completed a seismic hazard risk assessment. We have had our colleagues in Utah and California come in and share with us lessons learned. We have just finished a National Science Foundation symposium on how to strengthen these existing unreinforced masonry buildings.

Now I would like to elaborate on the threat for 1 minute that came out of the first meeting. It shows that we are just not exposed and concerned about the great earthquakes. We are having periodically the smaller scale earthquakes, and these are our projections on what we should expect.

This magnitude earthquake would cause damage to unreinforced buildings. This earthquake would cause damage to reinforced buildings. And, of course, this would cause widespread destruction—this being the 1886 event of Charleston.

Now going to the third lesson and the conference we just held on the seismic retrofit of existing buildings, I would like to show in conjunction with this an excerpt from a news broadcast by Gail Buckner which followed this conference on channel 2 in Charleston, SC.

It illustrates very well our state of being in the southeast and, secondly, the means by which we intend to transfer technology with the assistance of the Federal agencies and our sister States.

This one in particular was supported by the National Science Foundation; and the ABK joint venture from Los Angeles. Our keynote speaker was Dr. Butcher of the National Science Foundation—great interface. And the other transfer colleagues are those listed, including Pat Burke from Seattle. We also had our regional engineers and students in attendance.

Our objective is to take conference retrofit technology and transfer it into codes and effective methodology implementation. We hope to develop regionalized handbooks and design standards in the process.

So at this point, sir; let me interrupt my slide presentation near its end and show you the television report.

[A videotape was shown.]

Thank you, sir. I have three slides left.

Some observations we have made, sir; are these. First of all, grass roots involvement is very essential. That is the local engineers, for example. Early mitigation progress is very possible. Increased attention by Federal agencies. We have noted a lot more attention being devoted to our region, and, of course, a lot more is necessary.

Improving in-house FEMA capability. We notice that there is increased capability within FEMA and we encourage further growth, particularly of a technical capability. The ABE joint venture; we say a concern. The concern is not that it has been done. The concern, rather, is that it involve in a developmental way the southeastern technical community. We do not wish to stand aside and have reports given to us one day. We wish to be involved in the technology growth period.

And the Center for Building Technology. We state, sir; that there is a continuing need for that, as long as they are involved actively in the needs that we are talking about, working directly with our technical community.

These program initiatives we have basically already talked about, sir. They lead to collectively to the establishment in our region of a technology base and, in concert with that to building codes and good, sound seismic safety policy. We are down in these two fundamental respects. We need major progress along those two avenues. Technology and awareness increase and political, social and economic increase will lead to good, sound seismic safety policy.

So, in conclusion, we have a very high seismic safety hazard. Our seismic safety remains ineffective today. There is limited impact by the national programs. To date, we have not been involved as we should have been. It is partly our fault, too.

A patient revolution has begun. We know our need. We know the danger and threat to our public. We are going to do something about it, and we are confident we will have the support of our Congress and the Federal agencies, and the considerable integrated commitment of time and resources required.

I am sure, sir, you know that more than anyone else. Thank you very much for your patience, sir.

[The statement follows:]

Statement of Dr. Charles Lindbergh, Head, Department of Civil Engineering, The Citadel, Charleston, SC

I. Introduction

Mr. Chairman and other distinguished members of the Subcommittee, I sincerely appreciate this privileged opportunity to present my views on the seismic safety of our public in the southeastern United States.

The major accomplishments in earthquake hazard reduction and mitigation achieved under the provisions of the National Earthquake Hazard Reduction Program have not yet materially benefited the southeastern United States. Seismic safety developments remain those common to California several decades ago. This situation is particularly critical to the public in the southeastern region as there is as great a potential of earthquakes to kill and damage in the southeastern United States as there is in southern California and parts of other western states. Significant effort is required to meet the grave seismic hazards facing the southeastern communities.

In this testimony, I will present this matter by overviewing the serious seismic hazard within the southeastern United States, the state of public preparedness and mitigation efforts, and associated seismic safety needs. I will conclude by summarizing certain ongoing and planned program initiatives intended to bring the southeastern region abreast of California and other leading western states in regards to effective earthquake hazard reduction and mitigation. This effort will require considerable commitment of time and resources, including that of the federal government. However, the dire risk to the safety of our public leaves no responsible alternative to the patient seismic safety revolution now in progress.

II. Southeastern Seismic Hazard and Public Preparedness

2.1 East-West Differences in Seismic Hazard

There is great potential of earthquakes to kill and damage in the southeastern United States as there is in southern California and parts of other western states. This belief may seem to conflict with our personal experiences that the eastern United States does not experience the frequency of damaging earthquakes that occur in the western United States. Indeed, this difference in frequency of occurrence is one of the two major differences between eastern and western United States earthquakes. However, the other major difference is that which brings into balance the significance of the earthquake threats to these two regions. This difference is in the size of geographical area affected by ground shaking. Such size depends on the magnitude of the earthquake and the rate at which the amplitudes of body and surface seismic waves attenuate or rather decrease with distance from the epicenter. Comparison of the areas affected by the same Modified Mercalli Intensity (MMI) of ground shaking are shown in Figure 1 (Hays, 1981). In order to compare equivalent magnitudes,

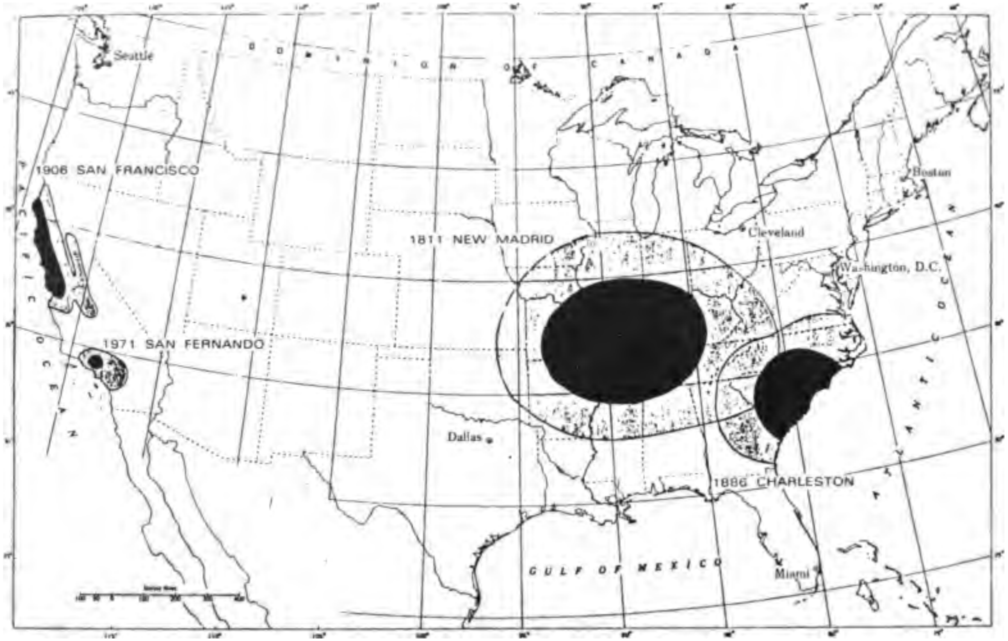


Figure 1

Comparison of isoseismal contours for earthquakes: the 1906 San Francisco and the 1811-12 New Madrid; the 1971 San Fernando and the 1886 Charleston. The contour lines connect sites having the same value of Modified Mercalli intensity. Each area shown in darker shade corresponds to an intensity of VII or greater and denotes the zone of most severe ground shaking and damage. The area shown in lighter shade corresponds to an intensity of VI; in this area the ground shaking is felt by all, many are frightened and run outdoors, but damage is slight. The effects of ground shaking extend over a much larger area in the Eastern United States.

one should compare the area affected by the great earthquakes of 1906 in San Francisco with the 1811-12 in New Madrid, Missouri, and the area affected by the larger earthquakes of 1971 in San Fernando with that of 1886 in Charleston. For a given intensity of ground shaking, a significantly larger area of the eastern United States is affected. These results underscore that the attenuation of ground motions extend to much greater distances in the east than in the west.

2.2. The Effects on Southeastern Preparedness Programs

The two differences in eastern and western United States play a dual role. In addition to distinguishing earthquakes of the two regions, they also are the two most critical factors distinguishing the seismic hazard reduction and mitigative programs of the southeastern United States with the more progressive efforts of the western United States. On the west coast of the United states, most people have been exposed to moderate-size earthquakes. This factor of increased frequency has resulted in strong local and state activities in the western states to increase seismic technical knowledge and promote achievement of public seismic policy. Congressional support provided through such federal agencies as the National Science Foundation, U.S. Geological Survey, National Bureau of Standards and the Federal Emergency Management Agency have focused on the western regional needs. The results have been commendable. Although significant technology development requirements remain, at least minimum seismic technical knowledge exists to support public awareness and safety policy establishment.

This progress has not been similarly achieved in the southeastern United States. The infrequency of large-magnitude earthquakes has resulted in complacency at the national as well as local levels. Despite the many technical and political advances made in the western region, little progress has been made in seismic hazard reduction and mitigation throughout the entire southeastern United States. The seismic safety posture is that of California several decades ago. Public policy developments regarding seismic safety have been insignificant. Even more disturbing is the unchanged persistent need to establish at least minimum adequate knowledge at all professional and public levels. We are not prepared to cope with the social and economic impacts from either a recurrence of a major earthquake like that of 1886 in Charleston or from smaller damaging earthquakes. But there is one major difference in opportunity. Now, our region has available significant technology and experience developed largely in the western United States.

2.3 Recent Studies Heighten Concern

Subsurface liquefaction is commonly caused by great earthquakes in regions of saturated sandy subsoil. The venting to the surface of such pressurized soil deposits has been known to have occurred during the 1886 earthquake event. However, recent USGS field investigations funded by the Nuclear Regulatory Commission have uncovered new evidence of subsurface liquefaction. These liquefaction sites, located in the Charleston area, show that there has been widespread liquefaction before 1886. In fact, at some of these sites, the 1886 liquefaction events cut through the older liquefaction events. The discovery of these sites demonstrate that the 1886 earthquake was not an isolated event. The Charleston area has been subjected to numerous great earthquakes. By analyzing various layers of vented soil and residue with carbon 14 dating techniques, the preliminary conclusions are that at least four other great earthquakes have occurred in the Charleston area that were at least as strong as the 1886 event.

2.4 Seismic Safety Program Needs and Objectives

In sober realization of these factors and with developing federal support and encouragement, significant effort has begun in our region to meet the seismic hazards facing our communities. Our basic essential needs, and hence objectives, are twofold. First, we must increase regional technical knowledge and capability through regional technical developments as well as technology and experience transfer from our sister western states. Seismic technology and policy developments are mutually dependent. Effective seismic policy can be established and sustained only by sufficient regional and local technical capability professionally supporting our communities. Early technical progress is prerequisite to initial advancements of seismic safety policy. Continued technical progress is prerequisite to sustained improved policy. Seismic safety policy will not be achieved without this supporting technology growth. Our region's educational and technology base relevant to earthquake engineering is in its early phase of development. Like experiences elsewhere illustrate, this critical technical base cannot be achieved through periodic workshops conducted by authorities from other national regions. Nor can it be seriously improved through technical references established in these regions. It can only be established in full cooperation with other national regions; however, with such cooperation involving strong regional participation in the conduct of national seismic research and engineering studies. Exposure to technology transfer workshops and literature distribution is not sufficient. Regional participation in seismic research and engineering development cannot be exclusively left to the dictates of routinely processed technical proposals and the paper review process. Such accommodation by administering federal agencies would perpetuate the southeastern technology deprivation by seriously compromising the earnest efforts of regional scientists and engineers who generally have not yet established impressive credentials in earthquake engineering research and development. It would continue to impede the effective technological development essential to the evolution of seismic safety policy in the southeastern United States. In my view, this issue is so clearly critical to the public welfare that Congress should act to insure the beginning of meaningful involvement of professionals from the southeastern United States. Perhaps similar congressional concern should be extended to those in the northeast and central states. Building upon intended improvement in the regional technology and experience base and increased public awareness, our second need is to achieve public adoption of effective seismic policy. Our approach is fundamentally different in that broad community level involvement is being developed prior to seeking the legislative mandating of seismic policy. This "grass roots" approach is to accelerate technology transfer to the lowest levels and to insure public acceptance of seismic safety legislation once enacted.

Considerable commitment of time and resources will be required, including that of the federal government. However, the dire risk to the safety of our public leaves no responsible alternative. The full commitment of the National Bureau of Standards, U.S. Geological Survey, National Science Foundation, Federal Emergency Management Agency and the U.S. Nuclear Regulatory Agency is essential to this task. The program demands are broad and involve the specific specialized responsibilities of each of these agencies. It is imperative that federal, regional, state and local efforts be well coordinated. We understand that FEMA has the major responsibility for such coordinated leadership.

III. Regional Seismic Safety Program Background, Organization and Status

3.1 Program Background

National seismic safety technology and program policy advancements generally have been limited to the western region of the United States. Noteworthy seismic program developments in Massachusetts are the only apparent exception. Certainly, much of the technology and experience basically developed in these other states are of strong potential benefit to the eastern states. However, this progress has not yet been made. Consequently, a considerable imbalance exists between the earthquake damage reduction and mitigation postures of the eastern and western United. In September 1981, a national conference was held in Knoxville, Tennessee, to address this imbalance. It marked the first time that engineers, geologists and planners assembled to discuss the many important issues related to earthquake hazards in the eastern United States. More importantly, it was the first major breakthrough in seismic technology and experience transfer to the eastern United States. Over six hundred people participated, reflecting wide felt concern of the public as well as government and technical communities. Most of the participants were from the eastern states.

3.2 Program Organization - Southeastern United States Seismic Safety Consortium (SEUSSSC)

Our current seismic safety program for regional seismic safety development was borne at the 1981 Knoxville conference. During the conference workshop sessions, a draft 5-year action plan was developed for improving earthquake preparedness and mitigation in the southeastern United States. The Southeastern United States Seismic Safety Consortium was established and an Ad Hoc steering committee to guide its continued development was appointed. The SEUSSC is to serve as the entity to refine and implement the recommendations of the draft action plan, evolving a seismic safety policy for the southeastern United States achieved through coordinated but independent sate seismic programs. Figure 2 illustrates the intended foundations of strong individual state seismic safety consortiums, eventually transitioning to official commission status. SEUSSSC functions as an integrative and coordinating organizational element for the individual consortiums of southeastern states. Technology transfer and definition of seismic research efforts for federal sponsorship are but two examples of anticipated benefits.

The cochairman of the Ad Hoc steering committee are myself, Dr. Charles Lindbergh, Head of the Civil Engineering Department, The Citadel, Charleston, South Carolina and Professor Joyce B. Bagwell of the Baptist College at Charleston, South Carolina. The three other committee members include Dr. Ajaya K. Gupta, Department of Civil Engineering, North Carolina State University; Dr. Leland T. Long, Department of Geology, Georgia Institute of Technology and Dr. Gilbert A. Bollinger, Department of Geologic Sciences, Virginia Polytechnic Institute and State University.

3.3 Program Organization - South Carolina Seismic Safety Consortium

The South Carolina Seismic Safety Consortium (SCSSC) was organized to develop and influence the implementation of a five year comprehensive action plan for earthquake preparedness and mitigation in South Carolina with emphasis on its lowcountry region. This effort builds upon the draft five year action plan developed at the Knoxville Conference and Workshop. The SCSSC includes approximately eighty-five (85) representatives of government, professional associations, universities and the public sector. This consortium is to serve as the prototype state program for other state consortiums in the southeastern United States, all of which are to be ultimately integrated for coordination under the newly developed southeastern United States Seismic Safety Consortium.

The South Carolina Seismic Safety Consortium has three major objectives. They are:

a. Act to develop and influence the implementation of a comprehensive state seismic safety policy insuring adequate earthquake preparedness and mitigation in South Carolina with emphasis on its lowcountry region.

b. To provide synergism and technical qualification among engineers, geologists, seismologists, planners, governmental leaders and the public as necessary to insure adequate sustained implementation of seismic safety policy.

c. To insure federal and state seismic research and development programs adequately address the technical needs of South Carolina and the southeastern United States.

The SCSSC is organized into five task groups as illustrated in Figure 3. The specific responsibilities of each task group are defined in Appendix A. As reflected in their leadership, the task groups include representatives of government, professional associations, universities, industry and the public sector. The consortium's organization including the five task groups and their chairmen are:

Consortium Cochairman

Dr. Charles Lindbergh, P.E.
The Citadel - Civil Engineering Department

Professor Joyce B. Bagwell
Baptist College @ Charleston - Chemistry/Geology Department

Consortium Task Groups

Hazard Awareness and Public Information Task Group

Mr. J. M. Wooten (Chairman)
Santee Cooper Public Service Authority

Local Earthquake Resistant Design Task Group

Colonel M. R. Harlan (Chairman)
The Citadel - Department of Civil Engineering

Response to a Damaging Earthquake Task Group

Mr. S. W. Kinard (Chairman)
City of Charleston Commissioners of Public Works

Sector Participation Task Group

Mr. Alex Dallis (Chairman)
Holmes & Thompson, Attorney at Law

Intergovernmental and Organizational Relations Task Group

Dr. Thomas Hansen (Chairman)

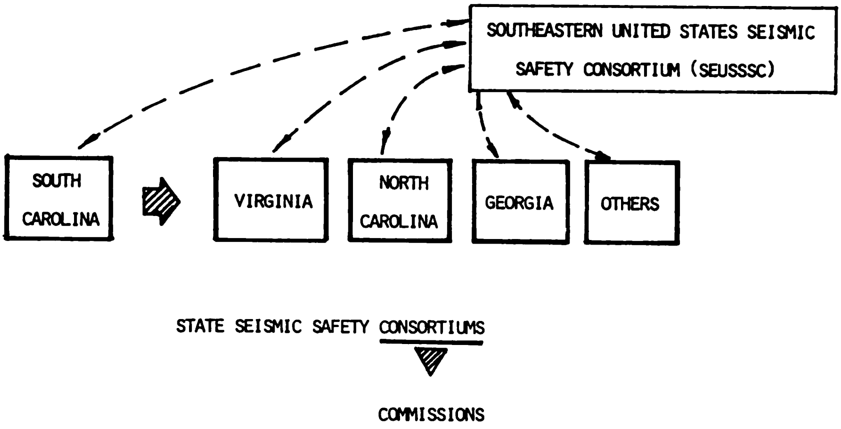

SOUTHEASTERN UNITED STATES SEISMIC SAFETY CONSORTIUM (SEUSSSC)
SOUTH CAROLINA
VIRGINIA
NORTH CAROLINA
GEORGIA
OTHERS
STATE SEISMIC SAFETY CONSORTIUMS
COMMISSIONS

Figure 2

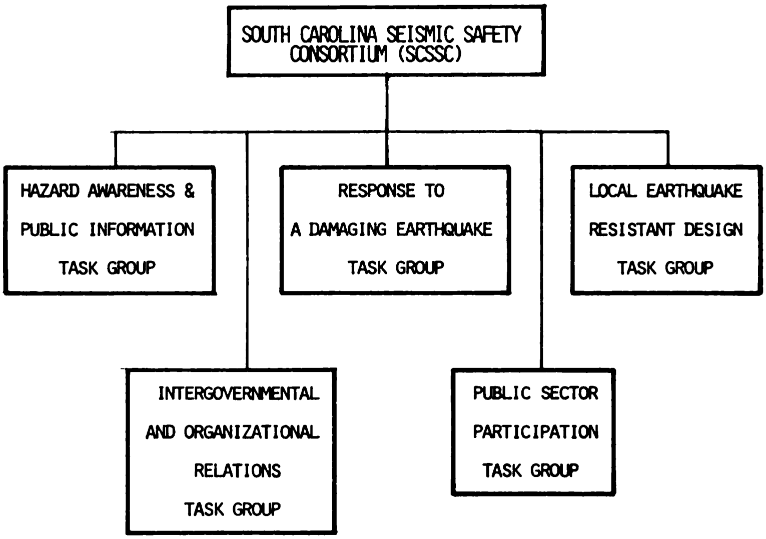

SOUTH CAROLINA SEISMIC SAFETY CONSORTIUM (SCSSC)
HAZARD AWARENESS & PUBLIC INFORMATION TASK GROUP
RESPONSE TO A DAMAGING EARTHQUAKE TASK GROUP
LOCAL EARTHQUAKE RESISTANT DESIGN TASK GROUP
INTERGOVERNMENTAL AND ORGANIZATIONAL RELATIONS TASK GROUP
PUBLIC SECTOR PARTICIPATION TASK GROUP

Figure 3

Director BCD Council of Governments

3.4 SCSSC Program Plan

The SCSSC program plan is structured to develop and implement a five year action plan for seismic safety improvements within South Carolina. Initial direction is being provided by the preliminary five year plan drafted at the Knoxville conference workshop. As illustrated in Figure 4, there are three programs phases. The first phase was one of consortium organization. The current or second phase of the three-phase effort is to allow South Carolina to share the seismic safety program experiences and engineering design technology accrued by certain other states, primarily in the western United States. This phase is to continue indefinitely. However, a six session series of meetings to underpin this phase has been identified and are in progress. Table 1 lists the session topics. Through this technology and experience transfer interaction, a common level of information and association will be established among SCSSC committee members regarding seismic risk awareness, relevant programs of federal and other state seismic safety groups and preparedness conditions within South Carolina. The SCSSC will be in a good position to chart the course of South Carolina's state seismic safety development.

TABLE 1

TECHNOLOGY AND EXPERIENCE TRANSFER PROGRAM

Session 1	Earthquake Hazards and Risk in South Carolina and the Southeastern United States
Session 2	Seismic Safety Planning Strategies; Lessons from Utah and California
Session 3	Seismic Retrofit of Existing Unreinforced Masonry Buildings (Technology Transfer & Development Council
Session 4	Seismic Safety Planning Strategies: The Northeastern and Central United States
Session 5	Earthquakes and Lifelines (Technology Transfer and Development Council)
Session 6	Seismic Design of Other Existing and New Buildings (Technology Transfer and Development Council)

Each session consists of a one or two-day workshop of interaction between particular SCSSC task group(s) and a set of participating consultants from other states and the federal government. In each case, the continued interface subsequent to the workshop between the conferees is intended to give final definition to a particular section of the five year plan and its implementation. While promoting highly specialized program developments, it is intended to further the overall seismic safety knowledge of the general membership (i.e., all five task groups). Informed integrated action is the necessary objective.

The first workshop was held at The Citadel in Charleston, South Carolina during May 17 and 18, 1982. It was designated "The Hazard Awareness and Public Information Task Group Workshop." As planned, it produced a white paper providing a consensus on seismic threat to the southeastern United States with emphasis on on South Carolina and its low country region, including Charleston. This document is entitled "Earthquake Hazards and Risk in South Carolina and the southeastern United States." It is intended to be the foundation for the five year seismic program in South Carolina and, to considerable extent, throughout the southeastern United States region. This definition of threat and associated prediction capability was resolved by the SCSSC's Hazard Awareness and Public Information Task Group, with the technical assistance of select consultants. It was based on the current state of relevant art and science. As a secondary objective, the workshop defined certain public actions and strategies capable of enhancing seismic prediction capability within the southeast. Figure 5 illustrates some extracts from the workshop's program. It lists the participating membership of the Hazard Awareness and Public Information Task Group and identifies the supporting invited technical consultants. This figure is significant in that it indicates breath of organization as well as notable participation by invited national consultants, stimulating technology transfer to our region.

The Hazard Awareness and Public Information Task Group concluded that "... there is sufficient likelihood that a major earthquake will occur in the Eastern United States, and very possibly in the southeastern United States, during our present generation." Based upon analysis of historical earthquakes in the southeastern United States and the frequency with which they have occurred, the recurrence interval for South Carolina and the southeast region were established for SCSSC planning as shown in Table 2. Appendix B defines the damage significance of the listed Modified Mercali Intensities (MMI).

Table 2

Recurrence Intervals for South Carolina and Southeast Region

	Approximate	Approximate Recurrence Interval	
MMI	Magnitude	Southeastern Region	South Carolina
VI	5	3 years	10 years
VIII	6	20 years	100 years
X	7	(?)	(?)

In its deliberations, the task group considered the Charleston earthquake of 1886. Appendix C provides a map of the city at that time, the isoseismals of that event, and photographs of actual damage. The rare records effectively capture the high degree of resulting devastation.

The national USGS worship was held in Charleston, South Carolina, during May 1983, to assess the eastern seismic hazard with considerable attention give the character and implications of the great Charleston event of 1886. The consensus of this group of national experts and specialists was that the SCSSC threat assessment was most valid as stated.

The second session, Seismic Safety Planning Strategies: Lessons from California and Utah, was held at the Baptist College near Charleston on November 15-16, 1982. The purpose of the workshop was for regional people to learn the lessons of seismic safety planning of California and Utah and determine how these lessons could be applied to the southeast, emphasizing South Carolina and its lowcountry region. The white paper on the southeastern seismic hazard developed earlier by the consortium was used as a background. Keynote speakers included:

Dr. Richard Olson,	Project Director, Seismic Safety Policy Research Center, University of Redlands Redlands, CA
Mr. Delbert B. Ward	Structural Facilities, Inc. Salt Lake City, Utah Formerly, Executive Director of Utah Seismic Safety Advisory Council
Mr. Earl Schwartz	Chief, Conservation Bureau Department of Buildings and Safety City of Los Angeles, CA

The workshop was attended by over seventy people of varied disciplines. Excellent news coverage resulted in extensive regional television, radio and newspaper articles. They are typical in their acceptance of the eastern earthquake hazard and concern that awareness and preparation are apparently grossly inadequate.

The third workshop was conducted at The Citadel, Charleston, South Carolina, during January 28-29, 1985, with the support of The Citadel Development Foundation and the National Science Foundation. The conference, arranged by the Technology Transfer and Development Council (TDDC) and examined the state of the art in seismic retrofit of existing unreinforced masonry buildings, including those which are of historic importance. The keynote speaker was Dr. William S. Butcher of the National Science Foundation. The conference featured the NSF retrofit methodology developed by the ABK Joint Venture consisting of three firms, Agbabian Associates (AA), S. B. Barnes (SBB&A), and Kariotis &

Associates (AA), all of the Los Angeles area. The methodology was presented by R.D. Ewing of AA, A.W. Johnson of SBB&A, and J.C. Kariotis of K&A. Seismic retrofiting in a manner sensitive to the character and fabric of old and historic resources was discussed. Related lectures were given by Mr. David W. Look, National Parks Service (Western Region), San Francisco, California, and Mr. Pardraic Burke, Building Systems Technology, Seattle, Washington. Dr. Steve Obermeier of the U.S. Geological Survey discussed new evidence of earlier great earthquakes in the Charleston area. This technology is to be further developed for adoption within the southeastern United States and should serve as the basis for a near-term building code provision for unreinforced masonry buildings.

The next session will be conducted later this year at the Baptist College at Charleston, featuring the experiences and recommendations of the two neighboring consortiums; the Northeastern United States Seismic Safety Consortium and the Central United States Seismic Safety Consortium. The fifth session is scheduled for the spring of 1986 at The Citadel in Charleston, South Carolina. It will feature earthquakes and lifelines. Certain west coast design firms, the National Science Foundation, the National Bureau of Standards and the Earthquake Engineering Research Institute will be asked to participate. As is the usual situation, participants will be expected to volunteer their services. The U.S. Geological Survey is providing partial funds.

IV. Some Relevant Changes in National Programs

During the past three years, additional attention has been placed on the eastern seismic hazard by federal and other national organizations. The Trial Design Program directed by the Building Seismic Safety Council (BSSC) was expanded to include certain eastern cities. This program is to assess the Applied Technology Council (ATC) amended ATC 3-06 Tentative Provisions for the Development of Seismic Regulations for Buildings. It is interesting to note the essential absence of eastern technical participants from this ATC project. The U.S. Geological Survey and the Nuclear Regulatory Commission have place increased emphasis on establishing the cause of the Charleston 1886 earthquake and its implications for assessment of the overall eastern seismic hazard. Recent liquifaction investigations are providing valuable insight into earlier great earthquakes in the Charleston, South Carolina area. Another important action planned by USGS is the first strong motion instrumentations of buildings to improve the understanding of the behavior and potential damage of structures under seismic loading and to acquire free-field strong motion data for the eastern United States. Installation of instrumentation is planned for buildings in Boston, Massachusetts and Charleston, South Carolina. In addition, FEMA has supported a study of seismic vulnerability for Charleston and a prototype earthquake education center at the Baptist College at Charleston, South Carolina. Increased emphasis is being placed on eastern earthquakes by the Earthquake Engineering Research Institute (EERI). Its new president, Dr. Bob Whitman of M.I.T., in the institute's February 1985 newsletter, declared that 'As the first non-Californian president, expanding EERI's attention "eastward" will be a particular concert to me.' Under EERI's direction, the Third U.S. National Conference on Earthquake Engineering is to be held in Charleston, SC, during August 1986, one hundred years following the great earthquake event of 1886.

However, there is considerable concern that major developments may be progressing to the further impediment of critical southeastern technology growth. One development is the recently issued National Earthquake Hazard Reduction Program Five-Year Plan. The plan was developed under the "free-hand direction of an "internationally known expert" acting with a group of twenty-five (25) representing all relevant disciplines and state/local governments to aid him in reviewing the NEHRP Five-Year Plan and a smaller group to act as advisory group." According to FEMA, this plan provides the "nation's policy for earthquake mitigation through the and of the decade." I do not believe there was effective coordination or participation by the southeastern United States in the development of this important national plan. Another development is the recently announced ABE Joint Venture and its assignment to develop for FEMA a strategic plan for reducing seismic hazards to existing buildings. ABE Joint Venture consists of the Building Seismic Safety Council (BSSC), the applied Technology Council (ATC) and the Earthquake Engineering Research Institute (EERI). The technical and socio-economic investigations to be conducted should involve professional representatives of the southeastern United States as regular participants and not as only coordinators or data sources. This is an important opportunity for technical growth within the southeastern United States regarding a matter of immediate concern and action -- the strengthening of existing buildings. Technical developments by these national organizations have not generally included any significant southeast regional participation. This is not to be critical of the organizations that have accounted for many valuable advancements in seismic safety and earthquake engineering. Rather, it is to emphasize the imperative need to increase their national effectiveness by rectifying a serious, long standing imbalance in regional technical participation and community benefit.

V. Certain Program Initiatives

As the technology and experience transfer and program development phase of the SCSSC's seismic safety program progresses, several specific program initiatives have been established and are being advanced as opportunities permit. They are listed in Table 3 and discussed below.

5.1 Encourage Early Explanation of Eastern Earthquakes

The cause of the Charleston 886 earthquake continues to require explanation. Such understanding must be accelerated and adequate definitions of the southeastern seismic threat achieved. Current investigations by the USGS and NRC should be supported with due priority. The seismic threat motivates the entire seismic safety program. Its definition deserves adequate prompt refinement.

5.2 Establish Technology Transfer and Development Council (TTDC)

As the federal government and our western counterparts proceed to upgrade seismic building code provisions in line with the "Tentative Provisions for the Development of Seismic Regulations for Buildings" (ATC 3-06) prepared by the Applied Technology Council, the southeastern United States continued to wrestle with the acceptance and implementation of the now aging seismic provisions of the Uniform Building Code or the Southern Building Code, Figure 6. A major impediment has been the essential absence of southeastern representation on the Applied Technology Council. Of the ninety (90) project participants identified in the ATC 3-06 report, only two are from the southeastern United States, both from Memphis, Tennessee. Usually, code development and acceptance require considerable time. However much utility is realized throughout the development process by the participants as they engage in continuing deliberations. Through them, community technology can normally be upgraded years ahead of final code adoption. This benefit has not been realized by the southeastern region as it essentially has not effectively been a participant. Wide concerted efforts are now being charted elsewhere to guide community acceptance of the more updated tentative code provisions. On the other hand, we continue to encourage effective implementation of standard UBC and SBC code provisions.

A technology transfer and development council has been formed to assist the regional state seismic safety consortiums and the southeastern United States Seismic Safety Consortium by establishing an earthquake engineering technology base in the southeastern region. The TTDC consists of representative from various southeastern states and would cooperate with ATC, EERI, NRC, FEMA, NSF and others to promote effective national representation of these organizations. In the process, it is to transfer technology, develop technology addressing unique regional needs and to provide other technical assistance.

5.3 Establish Adequate Technical Baseline Throughout the Southeast

Technical information and trained capability regarding seismic related technology is very limited throughout the southeastern United States. Broad improvement is necessary for

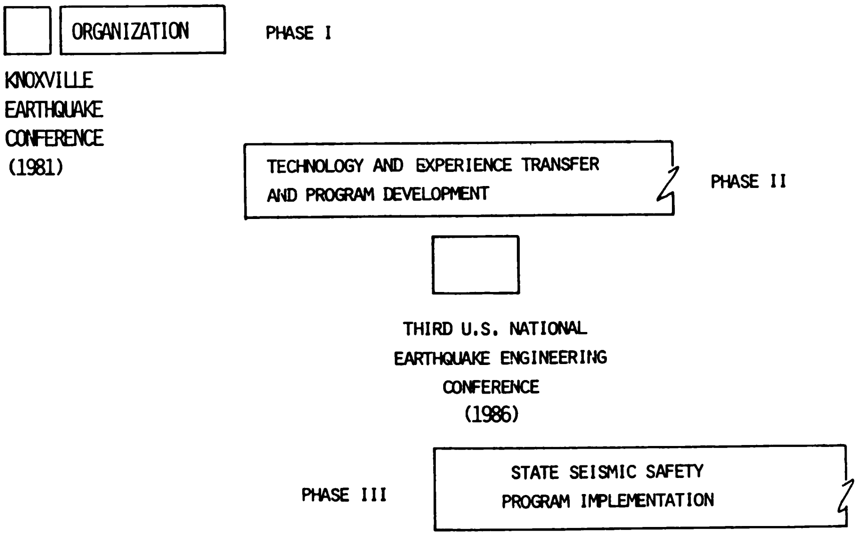
Table 3

CERTAIN PROGRAM INITIATIVES

- ENCOURAGE EARLY EXPLANATION OF EASTERN EARTHQUAKES
- ESTABLISH ADEQUATE TECHNICAL BASELINE
- PROMOTE VULNERABILITY STUDIES THROUGHOUT THE SOUTHEAST
- ESTABLISH OTHER STATE SEISMIC SAFETY CONSORTIUMS/COMMISSIONS
- ESTABLISH SENSIBLE CODE PROVISIONS
- DEVELOP REGIONAL TECHNOLOGY AND EDUCATION CENTERS
- CAPITALIZE UPON "WEST COAST" TECHNOLOGY

PROGRAM PLAN

Figure 4


ORGANIZATION
PHASE I
KNOXVILLE EARTHQUAKE CONFERENCE (1981)
TECHNOLOGY AND EXPERIENCE TRANSFER AND PROGRAM DEVELOPMENT
PHASE II
THIRD U.S. NATIONAL EARTHQUAKE ENGINEERING CONFERENCE (1986)
PHASE III
STATE SEISMIC SAFETY PROGRAM IMPLEMENTATION

the development and maintenance of adequate seismic safety policy. Several initiatives are currently being worked. First, a centralized regional seismic reference center is essential. None exist throughout the entire southeastern United States. Second, regional unique technical requirements exist. Regional seismic research and design development activity needs to be dramatically increased among the commercial as well as educational sectors. Training and experience derived from such technology acquisition would directly benefit the regular practitioner and public. In this regard, significantly increased EERI, FEMA, USGS and NSF support are mandatory. Third, seismic design instruction needs to be routinely offered in regional engineering centers. Fourth, much of the limited seismic design accomplished is the product of non-regional or western professionals. These opportunities in design and experience growth are being lost for local engineers. At least minimum participation by local engineers in all regional seismic design projects should be mandated.

5.4 Promote Vulnerability Studies.

Probably, one of the most important keys to successful public seismic safety policy is the community vulnerability study. The vulnerability study assesses the local earthquake hazard, and, considering the damage susceptibility of existing facilities and systems, determines the extent of probable community damage resulting from a likely seismic event. From this determination, the impact on the community is quantified in terms of killed or injured people, reduced critical services, etc. The current critical need for such studies in communities throughout our region is reflected in a recent letter to me by Mr. Thomas L. Hansen, Executive Director, Council of Governments Berkeley, Charleston and Dorchester Counties in South Carolina. His statement is simple but profound in that it captures public sentiment common in the southeastern United States and underscores the urgency of the vulnerability study in achieving code adoption, improved disaster preparedness and other seismic safety advancements. Mr. Hansen wrote, "Personally, I believe that most people in this region are aware of the fact that a major earthquake could occur at any time. I do not believe that they are aware of either the possible damages that could occur as a result of a major episode, or, of what may be done to mitigate damages."

Vulnerability studies have been concluded for only four cities in the entire United States; San Francisco, Los Angeles, Puget Sound and Salt Lake City. Several other cities in the central United States have initiated studies. In all cases, these studies have been led and largely conducted by visiting consultants and other technical study personnel. The SCSSC and The Citadel in Charleston, South Carolina, have commenced the first such vulnerability study in the southeastern United States. Its project director is Colonel Maurice R. Harlan, a faculty member in the Department of Civil Engineering at The Citadel. With valued FEMA support, this vulnerability study is being accomplished for Charleston, South Carolina. It is to serve as a prototype for the southeastern United States. Unlike all others, this study is being done by local people. The intent is to retain locally the technical experience that only comes from direct participation, to minimize study costs allowing more communities to likewise benefit and, finally, to produce a preliminary "vulnerability study handbook" for use by other regional communities. Significant technical assistance has been donated to our local vulnerability study team by several national consultants. They included Dr. Samy A. Adham, Agbabian Associates, Los Angeles, California; Mr. Henry J. Degenkolb, H.J. Degenkolb Associates Engineers of San Francisco, California; Dr. Winfred O. Carter, Utah State University, Logan, Utah; and Dr. Anschel Schiff, Purdue University, Lafayette, Indiana.

Certainly, the vulnerability study is emerging as a necessary element for a community's earthquake preparedness and hazards mitigation. Perhaps the Multi-Protection Design Summer Institute, Emergency Management Institute of FEMA located at Emmitsburg, Maryland, should be given an expanded role. Its curriculum should be expanded to include instruction to community engineers in the proper conduct of vulnerability studies. Instructional material should include technical handbooks on how community engineers can direct vulnerability studies. Only through such important measures will most communities be able to benefit from these evaluations.

5.5 Seismic Upgrade of Existing Buildings

Seismic strengthening is largely ignored in the restoration of old and historic buildings throughout the southeastern United States. This is of particular concern since the buildings are largely of unreinforced masonry construction and were of little seismic strength even when constructed decades ago. Due to age and weathering, they are even more inadequate today. Figure 7 is a photograph of some such old buildings in Charleston, South Carolina. The walls are commonly only stuccoed during restoration. No significant strengthening is usually achieved. Figure 8 shows the exposed wood roof truss of a building undergoing renovation. Careful examination reveals no incorporation of seismic upgrading measures such as the structural connection of the truss chords to the masonry wall section in the lateral direction. Figure 9 is a photograph of some historical buildings which have been "restored" in this manner. Certainly, they are attractive, appear substantial and give little indication of their significant seismic weaknesses. Builders, developers, the public and regional engineers need to be instructed in the economically feasible seismic strengthening measures possible within available technology that are consistent with their historic character. Certainly, historic buildings can be seismically strengthened without compromise of their historic character. Certainly, they must be. Otherwise, the public is deceived into assuming these often compromised facilities are stable for years

Figure 7

Figure 8

of safe future service. The correction of this condition can be encouraged through the federal historic restoration agencies that administer tax credits to those restoring such historic buildings. In review processes, compliance with applicable federal seismic upgrade provisions should be made prerequisite to tax credit allowances just as the more superficial aspects are mandated today. It seems unreasonable that some agencies of federal government fully understand the means and imperative need to strengthen such old buildings while other federal agencies freely administer such government subsidized restorations without dictating such precautions. In any event, procedures like that developed in Los Angeles for the practical seismic strengthening of old unreinforced masonry buildings have not yet been introduced and adopted in the southeast. The need is imperative.

As discussed in section 3.4, a technology transfer conference has been conducted to introduce NSF methodology developed by the ABK Joint Venture for the seismic retrofit of unreinforced masonry buildings. The immediate objective of the TTDC and SCSSC is to work in conjunction with ABK Joint Venture to complete the development of unreinforced masonry building retrofit technology for implementation within the southeastern United States. These developments will feature NSF methodology and the technology transfer begun with the SCSSC meeting in January 1985 at The Citadel. Figure 10 illustrates the process, beginning with The Citadel methodology conference. As illustrated, regional retrofit handbooks, training courses and design standards are to be developed in conjunction with building code definitions and implementation procedures. The code is to be first developed for adoption by the City of Charleston, South Carolina. The code proposal will then be prepared and processed to the Southern Building Code Congress International. Two members of the SCSSC are responsible building code officials who will be heavily involved in the local and regional initiative. Mr. Douglas Smits is the Chief Building Official and Public Safety and Housing Officer for the City of Charleston, South Carolina. He is President of the Coastal Code Enforcement Association and a member of the Board of Directors, South Carolina Building Officials Association. The other SCSSC member is Mr. Carl H. Simmons, President of the South Carolina Building Code Officials, a member of the Building Code Revision Committee, and Chairman of the Correlating Committee of the Southern Building Code Association International.

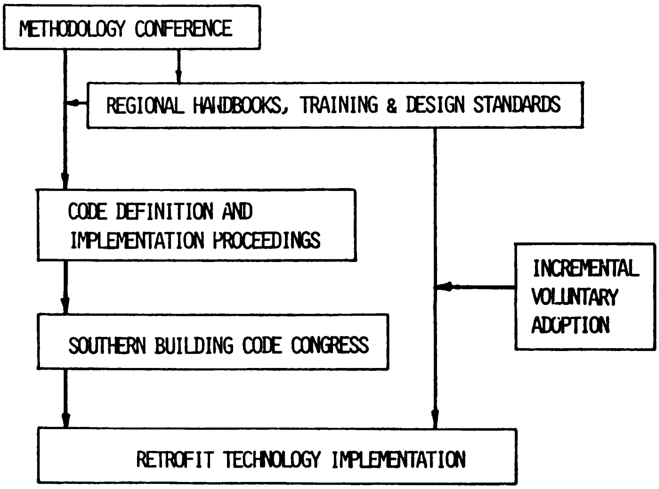
5.6 Demonstration of Technical Design Proficiency

Very few engineers practicing in the Southeastern United States have been adequately trained in earthquake engineering. No professional engineering examinations include seismic design exercises. These professional certification processes should more adequately protect the public welfare. Tests should be revised to include earthquake engineering principles and procedures. In the meanwhile, completion of an appropriate prescribed short

Figure 9

Figure 10

RETROFIT TECHNOLOGY IMPLEMENTATION


METHODOLOGY CONFERENCE
REGIONAL HANDBOOKS, TRAINING & DESIGN STANDARDS
CODE DEFINITION AND IMPLEMENTATION PROCEEDINGS
INCREMENTAL VOLUNTARY ADOPTION
SOUTHERN BUILDING CODE CONGRESS
RETROFIT TECHNOLOGY IMPLEMENTATION

course in seismic design should be required to promote technical sufficiency. Both restrictions are employed among the western states.

5.7 American Society of Civil Engineers Acceptance of Seismic Safety Responsibilities

Civil engineers are largely responsible for the public's environment and, hence, seismic safety. Civil engineers rightfully played a leadership role in the development of Massachusetts's seismic safety code, the only such state code in the eastern United States. Members of the Southeastern United States Seismic Safety Consortium are acting to encourage southern civil engineering state sections to form seismic safety technical groups and assume a lead role in advancing state policy. South Carolina and Georgia Civil Engineers have recently accepted these responsibilities. Missouri and North Carolina Civil Engineers are beginning to take these initiatives.

5.8 Establish Other State Seismic Safety Consortiums/ Commissions

The South Carolina Seismic Safety Consortium has served as a prototype for similar consortiums to be established in other southeastern states subject to seismic hazard. These seismic safety consortiums now need to be established. In addition to directly improving preparedness in the individual states, they would collectively enhance the technology and experience transfer required by the southeastern states. New technology would be improved.

5.9 Continued Development of the Southeastern United States Seismic Safety Consortium

VI. Conclusions

The major accomplishments in earthquake hazard reduction and mitigation achieved under the provisions of National Earthquake Hazard Reduction Program have not yet materially benefited the southeastern United States. Seismic safety developments remain those common to California several decades ago. This situation is particularly critical to the public in the southeastern region as there is as great a potential of earthquakes to kill and damage in the southeastern United States as there is in Southern California and parts of other western states. While western earthquakes occur more frequently, it is apparent that the far greater destructive capability of eastern earthquakes ranks the southeastern seismic hazard with that of the more notorious western national region.

Significant effort is required to meet the grave seismic hazards facing the southeastern communities. A concerted program has been launched by the Southeastern United States Seismic

Safety Consortium in concert with the South Carolina Seismic Safety consortium to bring the southeastern region abreast of California and other leading western states in regard to effective earthquake hazard reduction and mitigation. There are two main objectives; increased technical knowledge and capability and, secondly, the achievement of public policy. This effort will require considerable commitment of time and resources, including that of the federal government. However, the dire risk to the safety of our public leaves no responsible alternatives to the patient seismic safety revolution now in progress.

Regional professionals must be allowed meaningful involvement in the development of national earthquake engineering technology. They must be supported in satisfying regionally unique technology demands and in providing timely advice to our communities. The full support is necessary of the National Science Foundation, United States Geological Survey, Federal Emergency Management Agency, the United States Nuclear Regulatory Agency and the National Bureau of Standards (Center for Building Technology). The program demands are broad and involve the specific specialized responsibilities of each of these agencies. With this essential assistance and that of our considerate colleagues in the western regions, reasonable levels of seismic safety can be and must be achieved in the Southeastern United States.

Senator GORTON. Thank you, Doctor. I have at this point one question for you.

From your perspective as a civil engineer, can you comment on the usefulness of the National Bureau of Standards Center for Building Technology program in making buildings safer? Is it important to you?

Dr. LINDBERGH. Sir, I have discussed this potential use with Dr. Leindecker and others at the center, and the basic response is we have not seen much in terms of direct interface with the center to this point. We do know they have been involved in very vital things, such as the strengthening of unreinforced masonry.

We see this. We say we need them. We need them, however, to more directly interface with our regional efforts and engineers to help us integrate better the many Federal actions that are ongoing, to help us grow the codes that we need to evolve in the southeast. So we do need them, but we need them to perform in a different way, at least from our perspective, sir. We need direct exposure.

Senator GORTON. Thank you.

Hugh, how effective are programs to apply things learned in California to the Puget Sound area, and how important is the Federal involvement in the transfer of the technology?

Mr. FOWLER. I think that we are receiving a great deal of benefit from what is happening and what has happened in California. In the fall of 1983 there was a national earthquake conference held in Seattle, with quite a number of the people in attendance that are working on preparedness measures down there. I think the southern California earthquake preparedness project put on a very good presentation.

Wherever possible we are interrelating and interacting with those people to the maximum extent.

Senator GORTON. Do you do that directly or through Federal agencies?

Mr. FOWLER. We do it directly. We talk back and forth. In fact, I am planning to send the person on my staff who works on earthquake preparedness down to watch an exercise there shortly.

Senator GORTON. Do the results of research conducted by the Geological Survey and the National Science Foundation and the National Bureau of Standards reach the Washington State Department of Emergency Management quickly and effectively?

Mr. FOWLER. I believe so, and I want to clarify my remarks. I am not in competition with them. I think the scientific and the engineering studies that are set forth in the 5-year plan are necessary, and I do not want to leave an understanding that I do not believe that.

We talk with the agencies quite often. We have what we call the Western States Seismic Policy Council, which is a group of about, I believe, 12 States in the West that meets periodically, and at each of those meetings the Bureau of Standards, USGS, National Science Foundation, and FEMA representatives attend, and it is a good network. It is very informal, but very valuable.

Senator GORTON. Thank you both. Any additional questions we have in writing we will submit to you very promptly. I want to thank both of you for coming to this hearing and sharing your knowledge and experience with us.

We are adjourned.

[Whereupon, at 11:52 o'clock a.m., the subcommittee adjourned, to reconvene upon the call of the Chair.]

ADDITIONAL ARTICLES, LETTERS, AND STATEMENTS

STATEMENT OF JAMES DAVIS, STATE GEOLOGIST, STATE OF CALIFORNIA

The following commentary outlines the efforts of the U.S. Geological Survey as part of the National Earthquake Hazards Reduction Program efforts within California. Other state officials will have the opportunity to comment on the efforts of the Federal Emergency Management Agency and also the engineering efforts under this Act.

Under the National Earthquake Hazard Reduction Act, the U.S. Geological Survey (USGS) maintains several important earthquake-related programs which are important to California. These include regional monitoring of earthquakes, assessment of earthquake hazards, earthquake prediction experiments, volcanic hazards assessment and support of earthquake studies by non-Federal scientists.

Regional Monitoring.—The USGS is making significant contributions which are important to the State scientific work on earthquakes which is also in progress. The USGS has pioneered the technology of computer processing regional monitoring network signals to locate the epicenter and depths of earthquakes within near real time. The State and other parties now have access to this technology. The USGS maintains over 500 seismograph stations in California. The Division of Mines and Geology has arranged access to some of these signals.

Hazards Assessment.—The USGS has undertaken delineation of earthquake hazards in several portions of the State. A very comprehensive evaluation of ground failure conditions, ground shaking and fault mapping has been synthesized in a *Professional Paper* which will be released during 1985. This work will be very helpful in hazard mitigation.

Prediction Experiments.—The USGS has the unquestioned lead responsibility in earthquake prediction research in the scientific community. In California, this work includes geodetic networks on segments of the San Andreas fault to detect crustal strain. The regional monitoring network is important in efforts to detect foreshocks. At Parkfield, where a M 5½ to 6 earthquake is anticipated during the next few years, the USGS has a comprehensive cluster of instrumentation which in addition to geodetic measurement and seismic monitoring, also includes downhole strain measurements, creepmeters and tiltmeters. This work is extremely important because of the refinement and improvement of the instrumentation and techniques applicable to short-term prediction, and to answer the scientific questions about the feasibility of developing a short-term earthquake prediction (a lead time of hours to weeks). The State is working closely with the USGS at Parkfield. The State maintains the strong motion instrument network at Parkfield. The State is coordinating with the USGS to oversee response to any short-term predictions which may derive from this experiment.

Volcanic Hazards Assessment.—The USGS has provided seismic monitoring in the Mammoth Lakes area which is important to assessment of the imminence of volcanic eruption. The State is also maintaining a specializing monitoring which is coordinated with the USGS effort to assure appropriate and timely advice is available on the hazard potential in the area. The USGS is also providing the geodetic and geochemical analyses which are important to this comprehensive effort to predict any volcanic activity which may occur in the area.

The Outside Funded Program for Hazard Assessment and Earthquake Research.—The annual grants program of the USGS awards research support funding to University and non-Federal scientists on earthquake research which is pertinent to hazard reduction. This funding has made it feasible for a considerable amount of important research to be done which is having a significant influence on priorities for earthquake hazard reduction within the State.

EARTHQUAKE ENGINEERING RESEARCH INSTITUTE,
Berkeley, CA, March 14, 1985.

Hon. SLADE GORTON,
U.S. Senate, Subcommittee on Science, Technology and Space,
425 Hart Senate Office Building, Washington, DC.

DEAR MR. GORTON: I am writing as President of the Earthquake Engineering Research Institute (EERI) in support of reauthorization of the National Earthquake Hazards Reduction Act of 1977.

EERI is a professional society with over 1100 members concerned with earthquake hazard mitigation. Our members include architects, engineers, seismologists, geologists, building officials and other local governmental officials, urban planners and other disciplines. There are both practitioners and researchers in our membership. EERI is a national organization with members in most of the 50 states. (The fact that I, as president, am from Massachusetts, is additional testimony to our national character.)

I am sure that the accomplishments of the National Earthquake Hazards Reduction Program have been spelled out for you in great detail. I will highlight only a few:

Research has led to development and use of better and more economical structures for resisting earthquake ground motions, such as the eccentrically braced frame.

There are much improved and better-tested methods for evaluating and strengthening existing buildings.

The private sector and governmental agencies at various levels have formed together to develop public awareness and post-disaster plans.

The earthquake hazard has been much better defined in many areas through seismological and geological studies.

I could go on, but am confident that our people and commerce are measurably safer today than they were in 1977.

At the same time much still remains to be done in all aspects of the problem. These continuing needs are documented in the 5-year plan submitted to Congress by the Federal Emergency Management Agency. This is, in general, a good plan. It is at the same time a minimum plan; several times the proposed amount could be spent efficiently so as to move as rapidly as possible toward a minimization of the earthquake hazard. I also feel it is unfortunate that the Center for Building Technology at the National Bureau of Standards is eliminated from the plan; they have some unique and very important experimental facilities plus valuable expertise in assisting code writing groups. However, at least this minimum plan must go forward in order to continue progress toward improved public safety, to protect our national security and to prevent further deterioration of the competitive position of the American construction industry in international markets.

Sincerely yours,

ROBERT V. WHITMAN, *President.*

SEISMIC SAFETY COMMISSION,
Sacramento, CA, March 15, 1985.

Hon. SLADE GORTON,
Committee on Commerce, Science and Technology,
United States Senate, SH 427, Washington, DC.

DEAR SENATOR GORTON: I am writing on behalf of the California Seismic Safety Commission to request authorization of the National Earthquake Hazards Reduction Act of 1977 and funding of the program at the levels recommended in the Five-Year Plan prepared by the Federal Emergency Management Agency.

The Seismic Safety Commission is an independent Commission established to advise the Governor and Legislature on earthquake safety policy. The Commission establishes state goals and priorities in earthquake safety and preparedness, gathers, analyzes and disseminates information, encourages research and its applications, and recommends needed legislation. The Commission's charge and ten years experience places it in a unique position relative to the National Earthquake Hazards Reduction Program.

The earthquake problem is unusual in that the effects of a great earthquake may be catastrophic, yet the interval between such events is relatively long. The problem is further complicated because the location and time of occurrence of such events cannot be predetermined at the present time. It is generally believed that a large earthquake is likely to occur in California with the next 30 years, but historically, some of the largest events have occurred outside of California; for example in New Madrid, Charleston, and Anchorage. The problem of seismic safety has become critical to the national economy and security as a result of the growing concentration of population and economic base within the seismically active areas in the country. For example, much of the nations high technology industry is located in regions of known high seismicity.

As a consequence of the National Earthquake Hazards Reduction Act, significant strides have been made in reducing the earthquake hazard. However, much remains to be done. The State of California has worked closely with the different agencies involved in the federal program and we believe that this cooperation has multiplied the effectiveness of the program. The State is working with the Federal Emergency Management Agency in the development of earthquake preparedness programs for both southern California (the SCEPP Project) and the Bay Area (the BAREPP Project). The State also works with the U.S. Geological Survey in the measurement and interpretation of seismic data. The establishment of a major stated funded strong motion measurement program has allowed the U.S. Geological Survey to devote a great portion of its resources for this activity outside of California. In addition, the State draws heavily on the results of research conducted and supported by the U.S. Geological Survey by members and research groups funded by the National Science Foundation. This research is of critical importance in mitigating the results of earthquakes. It is only through such research that we will achieve any significant advances in our understanding of the earthquake process, the behavior of manmade structures, and the socio-economic factors involved. Reducing either the U.S. Geological Survey or National Science Foundation programs would have very serious negative consequences.

The National Earthquake Hazards Reduction Program provides a coherent approach to earthquake hazard reduction and a minimal level of federal support for this important national problem. Funding through the program supports vital, results-oriented efforts needed to address earthquake hazards. The continuation of a well managed and balanced the program is absolutely essential if we are to mimize the social and economic impact of major earthquakes in the United States.

We thank you for your consideration and respectfully submit this letter as part of your committee's record.

Very truly yours,

BRUCE A. BOLT, *Chairman.*

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